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There and Back Again: A Simple Theory of Planned Return Migration†

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Abstract

We present supportive empirical evidence and a new theoretical explanation for the negative selection into planned return migration between similar regions in Germany. In our model costly temporary and permanent migration are used as imperfect signals to indicate workers' high but otherwise unobservable skills. Production thereby takes place in teams with individual skills as strategic complements. Wages therefore are determined by team performance and not by individual skill, which is why migration inflicts a wage loss on all workers, who expect the quality of their co-workers to decline. In order to internalise this negative migration externality, which leads to sub-optimally high levels of temporary and permanent migration in a *laissez-faire* equilibrium, we propose a mix of two policy instruments, which reduce initial outmigration while at the same time inducing later return migration.

JEL-Classification: R23, J61, D82,
Keywords: Return migration, signalling, selection, strategic complementarity

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1 Introduction

Theories of temporary migration can be classified into two broadly defined categories, depending on whether the migrant's return decision is either optimally planned or an unanticipated but necessary choice. Planned return migration as integral part of an optimally designed life-cycle migration scheme thereby typically has the migrant in the role of an arbitrageur, who capitalises on institutional difference, which play out differently over the migrant's life cycle. Prominent examples include student migration (cf. Dustmann, 2001; Dustmann and Weiss, 2007; Dustmann, Fadlon, and Weiss, 2011) and the temporary migration of guest workers (cf. Ethier, 1985; Djajic and Milbourne, 1988; Djajic, 1989, 2010, 2013; Dustmann and Kirchkamp, 2002; Mesnard, 2004; Brücker and Schröder, 2012), which are both driven by strong institutional asymmetries (e.g. low costs of human capital accumulation abroad versus high returns to education at home). In the absence of such strong institutional differences unanticipated return migration typically is modelled as the revision of an erroneous initial migration decision in response to a random income/taste shock (cf. Borjas and Bratsberg, 1996; De la Roca, 2017).

In this paper we propose a simple signalling mechanism as a new theoretical explanation for planned return migration in the absence of regional asymmetries. Workers in our model differ in terms of their privately known skills, which are the sole input into a production process, that requires teamwork, and that is characterised by strong complementaries, as in Kremer (1993).[1] Due to the information asymmetry the otherwise optimal positive assortative matching of workers is no longer an option. Employers therefore resort to a second-best matching strategy, that combines only workers, which in expectation have the same skill. Since mismatch is an inherent feature of such a hiring regime, there is an incentive for high-skilled workers to avoid potentially "bad" matches with less skilled co-workers by signalling their true but otherwise unobserved skill through selection into costly temporary or permanent migration. Firms take into account workers' migration histories as an easy-to-verify signal, and form more efficient and better paid job matches, which renders migration attractive even without gains from arbitrage.

If the costs of permanent migration exceed the costs of a temporary stay, only the most

[1] Examples of strategic complementaries in the migration literature include Hendricks (2001), Giannetti (2001), Dequiedt and Zenou (2013), as well as Kreickemeier and Wrona (2017).

high-skilled workers select into permanent migration as the high-cost signal, which is compatible with a positive selection into initial migration and an *ex ante* negative selection into return migration. Migration flows thereby are not directed – as it is not the destination but the mobility as such that promises higher (expected) wages for migrants.

To motivate our theoretical analysis we explore the pattern of and the selection into regional return migration in Germany and establish two stylised facts, which we mean to explain by our theory of planned return migration between symmetric regions: At first, we shown that there is a considerable amount of two-way migration between fairly similar regions in Germany. Initial migration and later migration flows are remarkably balanced in the sense that we often observe migrants of the same type moving into exactly opposite directions. In a second step, we then follow De la Roca (2017), and provide some additional evidence in favour of an *ex ante* negative selection into planned returned migration based on workers' pre-migration wages, which are a comprehensive summary measure capturing all observable and unobservable income determinants (cf. Hunt, 2004). As in De la Roca (2017) we thereby exploit a rich administrative data set to follow individuals over their work lives. While both of these findings are well in line with our theory of planned return migration between symmetric regions, they are rather difficult to reconcile with standard theories of planned return migration between asymmetric regions or unanticipated return migration between *ex ante* symmetric regions.

Modelling planned return migration as a form of arbitrage between asymmetric regions typically implies welfare gains for the arbitrageurs (i.e. temporary migrants). Focusing on a setting without regional asymmetries, we would not expect these kind of welfare gains to matter, and indeed the welfare effects in our model contradict conventional wisdom in so far as all workers (including the migrants) tend to be worse off in an *laissez-faire* equilibrium with temporary and permanent migration than in an equilibrium without migration. Instrumental for the aggregate welfare loss is a negative migration externality, which leads to excessive temporary and permanent migration in the presence of wasteful migration costs.

The negative external effect of migration in our model is a direct consequence of the suboptimal matching of workers in the presence of asymmetric information. Due to the production in teams of two the shared payoff to each team member necessarily is a function of the respective co-worker's expected skill. Migration alters the composition and quality of the co-orker pool, which immediately feeds back not only into the wages of the critical (return) migrant but also into the wages of all workers, whose co-workers are hired from the thus affected group of workers. The critical (return) migrant rationally ignores the negative external effects on other workers' wages. As a consequence we observe excessive temporary and permanent migration, that is associated with wasteful periodical costs. Aggregate production gains, which emerge from a more efficient matching of workers within firms, thereby are completely consumed away by the periodical costs of excessive temporary and permanent migration, which renders the *laissez-faire* equilibrium socially inefficient. Of course this does not mean that all migration, temporary or permanent, is socially harmful per se. Employing an omniscient social planner we find that – if the periodical migration cost are not too high – the socially optimal equilibrium may feature temporary *and* permanent migration, both – of course – at a smaller scale than in the *laissez-faire* equilibrium. The social-planer solution thereby – as we show – can be implemented by a carefully chosen combination of taxes and subsidies, that aim for lower initial mobility and increased return activity.[2]

In order to demonstrate the robustness of temporary and permanent migration as signalling devices we show in an extension to our baseline model that temporary and permanent migration can also be combined with other signals. While there is some crowding out if the cost of migration/signalling are too high, we also find that the most high-skilled workers will always combine multiple signals in order to differentiate themselves from their lower skilled counterparts.

The positive selection into internal or regional migration within single countries is a well established empirical fact (see Greenwood, 1997, for a review of the literature).[3] Using NLYS data from the United States Borjas, Bronars, and Trejo (1992) show that more educated workers are more likely to migrate regardless of their state of origin. Focussing on migration between West-German federal states Hunt (2004) finds that migrants are more skilled than stayers. More recently, De la Roca (2017) has uses administrative data from Spain following individuals over their working lives to show that migrants to big cities are positively selected

[2] Benhabib and Jovanovic (2012) determine the globally optimal degree of (temporary and permanent) international migration. Djajic and Michael (2013), Djajic, Michael, and Vinogradova (2012), and Djajic (2013) study optimal policy instruments in the context of (temporary) guest-worker migration.

[3] Focussing on internal migration in Germany, Bauernschuster, Falck, Heblich, Suedekum, and Lameli (2014) argue that educated and risk-loving people are more mobile over longer distances because they are less afraid of crossing cultural boundaries and of moving to regions that are culturally different.

with regard to their education and their pre-migration income. The initial positive selection into migration thereby typically gets reinforced by the fact that return migrants tend to be negatively selected in comparison to the initial set of movers (cf. DaVanzo, 1983; Kennan and Walker, 2011; De la Roca, 2017).[4]

In order to explain the negative *ex ante* selection of workers into return migration between similar regions, we extend the static two-way migration model by Kreickemeier and Wrona (2017) to allow for temporary *and* permanent migration. We thereby develop a new purely graphical representation of Kreickemeier and Wrona's (2017) central matching result in a labour market with complementary skills à la Kremer (1993) and asymmetric information in the spirit of Spence (1973).[5]

Stark (1995b) and Hendricks (2001) both study the selection into (international) return migration when migrants are matched under asymmetric information. In order to generate a negative *ex post* selection into return migration Stark (1995b) assumes that employers learn the true skills of migrants over time (see also Katz and Stark, 1987; Stark, 1995a). Once information symmetry is restored all migrants are paid the marginal product of labour (instead of an average wage). Low-skilled workers, which in the absence of averaging would not have to migrated, then have an incentive to return home. In an extension to Hendricks's (2001) baseline model migrants can use costly return migration to signal their true but otherwise unobservable skills, which leads to a positive *ex ante* selection into return migration.

Focussing on inter-city migration in Spain De la Roca (2017) combines institutional differences between large and small cities with uncertainty about *ex post* outcomes to generate a negative *ex ante* and *ex post* selection into asymmetric return migration from large to small cities. See also Borjas and Bratsberg (1996) for a theoretical model, that combines the same two features (asymmetries versus uncertainty) to explain the outmigration of foreign born in the United States.

[4]Studies on international return migration typically focus on a single country or a small group of countries (see Borjas and Bratsberg (1996) for the US, Dustmann and Weiss (2007) for the UK, and Aydemir and Robinson (2008) for Canada, as well as Dustmann (2003) for Germany). Co, Gang, and Yun (2000), de Coulon and Piracha (2005), and Ambrosini, Mayr, Peri, and Radu (2015) report evidence from Hungary, Albania, and Romania, respectively. Gibson and McKenzie (2012) followed high-talented top-performers from five typical "brain drain" countries (Ghana, Micronesia, New Zealand, Papua New Guinea and Tonga). A more detailed review over the respective literature is given in Dustmann and Glitz (2011).

[5]See also the study of von Siemens and Kosfeld (2014), who extend a screening version of Spence's (1973) static job market signalling model to allow for strategic complementaries between workers in the spirit of Kremer (1993)

Our paper is structured as follows: Building up on the stylised facts on regional return migration in Germany from Sections 2, we develop in Section 3 a simple model of planned return migration between similar regions. Section 4 contains the welfare analysis and is used to derive the optimal migration policy mix. In Section 5 we extend the model to allow for an alternative signalling device. Section 6 concludes.

2 Stylised Facts on Regional Migration

As highlighted in the introduction, there are two dominating explanations for return migration: On the one hand, there is the notion of planned return migration as part of an optimal life-cycle migration scheme, that is designed to exploit institutional asymmetries across regions and/or countries (e.g. student migration (cf. Dustmann, 2001; Dustmann and Weiss, 2007; Dustmann, Fadlon, and Weiss, 2011) or guest-worker migration (cf. Ethier, 1985; Djajic and Milbourne, 1988; Djajic, 1989, 2010, 2013; Dustmann and Kirchkamp, 2002; Mesnard, 2004; Brücker and Schröder, 2012)). On the other hand, return migration also is explained as the *ex ante* unintended and unanticipated revision of an erroneous initial migration decision (cf. Borjas and Bratsberg, 1996; De la Roca, 2017).

To motivate our theoretical analysis from Section 3 we establish in the following two stylised facts on planned return migration between similar regions, which in combination are difficult to reconcile with either of the two aforementioned explanations for regional return migration. In particular, it is shown that inter-regional (return) migration between German regions is remarkably balanced in the sense that we observe a considerable number of initial and return migrants, which move into opposite directions. The existence of two-way return migration clearly is ad odds with an explanation that is derived from regional asymmetries, but is easily rationalised within a random utility framework, in which migrants learn about the true nature of their initial migration choice only upon arrival. In such a setting all initial migrants would have the same expectations regarding their return probabilities, such that we should not expect to find differences in the selection into initial migration, when conditioning on migrants later return decisions. Using initial wages as a proxy for worker's unobservable skills (cf. Hunt, 2004; De la Roca, 2017), we actually find that the positive selection into initial migration is more pronounced for permanent and onward migrants than for return migrants, which we interpret as indirect evidence for planned return migration.

We organise the remainder of Section 2 as follows: In Subsection 2.1 introduce our data set and provide some descriptive statistics. We proceed in Subsection 2.2 by showing that there is a considerable amount of inter-regional two-way migration. In Subsection 2.3 we then show that there are differences in selection into initial migration, when conditioning on workers' later return migration decisions.

2.1 Data and Descriptive Statistics

Our main data source are the Integrated Employment Biographies (IEB) provided by the Institute of Employment Research (IAB) in Nürnberg. We use a 4% random sample of the IEB V12.00.00-2015.09.15., which covers the universe of all workers in the German labour market except for those which are civil servants or self-employed (see also Card, Heining, and Kline (2013) and Oberschachtsiek, Scioch, Christian, and Heining (2009) for a detailed description of the data). The Integrated Employment Biographies link workers' employment history (including unemployment spells) to a detailed set of employer characteristics (including the place of work) from the Establishment-History-Panel (BHP). Our sample covers the time period from 1975 to 2014 (in some specifications we focus on the time period from 1992 to 2014 in order to avoid one-time reunification effects). Using the longest spell in each year we are able to construct a panel that is informative about workers mobility history (approximated by the location of the worker's workplace). Focussing on 402 German NUTS-3 regions ("Kreise") we associate the location of workplaces with the position of the largest city within the respective region. We then conduct our analysis at the level of 96 local labour markets ("Raumordnungsregionen"), which consist of several adjacent NUTS-3 regions that are summarised to commuting zones. Figure 11 from the Appendix illustrates the division of Germany into these 96 local labour markets, which can be classified as: rural, urbanised or metropolitan areas. Following De la Roca (2017) we use workers' employment history to learn about their mobility choices. Since short- and long distance migration seems to be driven by quite different motives (cf. Hunt, 2004), we focus only on long-distance migrants, who have migrated over distances of more than 120 kilometre and who stayed at their new location for at least two consecutive periods.[6] We then can distinguish between three different types of

[6]We adopt the 120 kilometre threshold from De la Roca (2017). Using information on the place of residence, which is available from the millennium onwards, it is possible compute workers' exact commuting distances, which rarely exceed De la Roca's (2017) distance threshold. To make sure that our results are not driven by

Table 1: *Descriptive Statistics*

Descriptive Statistics:						
Migration Type:	**Non-migrants**	**Short-distance**	**Permanent**	**Return**	**Onward**	**Total**
Number of Workers:	486,850	369,574	86,874	33,792	14,188	991,278
Wages:						
Monthly Wage in 2005:	2,696.58 EUR	2,777.74 EUR	3,250.70 EUR	3,203.98 EUR	3,830.26 EUR	2,827.11 EUR
Top-coded Wages:	3.2%	4.3%	9.8%	9.1%	16.2%	4.8%
Education:						
no training	9.6%	3.7%	3.0%	1.6%	1.4%	5.9%
vocational training	80.3%	81.1%	66.8%	72.3%	56.7%	78.6%
some college	1.8%	3.0%	3.9%	4.6%	4.6%	2.7%
university	8.3%	12.1%	26.3%	21.5%	37.3%	12.8%
Employment Status:						
part-time	14.2%	13.6%	13.7%	12.3%	11.3%	13.8%
public						
unemployed	3.3%	4.8%	5.2%	6.0%	5.4%	4.3%
in training	9.2%	9.6%	9.0%	8.7%	8.5%	9.3%
Gender:						
female	50.3%	47.2%	48.5%	45.0%	42.0%	48.4%
Number of Observations:	6,155,812	6,660,521	1,443,117	694,187	257,984	15,211,621

migrants: permanent migrants, return migrants and onward migrants. Permanent migrants remain within a 120 kilometre range of their initial migration destination. Return migrants move back to their origin region and subsequently stay within a 120 kilometre range of their return migration destination. Onward migrants move to a third location, which is at least 120 kilometre away from the initial migration destination and also 120 kilometre away from their origin region.

In Table 1 we provide some first descriptive statistics for the different migration types in our sample. Our sample consists of 991,278 workers, which are born between 1957 and 1995. Roughly half of the workers never move within our time frame (life time mobility may be higher of course). Another 37.3% of the workers only move within a 120 kilometre range. There are 13.5% long-distance migrants, of which 8.7% are classified as permanent migrants, 3.4% are classified as return migrants, and another 1.4% are classified as onward migrants. Non-migrants and short-distance/term migrants have the lowest wages. Onward migrants have the highest wages among all migrants, and return migrants earn lower wages than permanent migrants, which is in line with the results from Hunt (2004) and De la Roca (2017).[7] A similar ordering is obtained when considering workers' education: Migrants are more educated in general. Among the mobile workers, onward migrants are the most edu-

outliers we exclude all workers who migrate more than 10 times (irrespective of their moving distances).

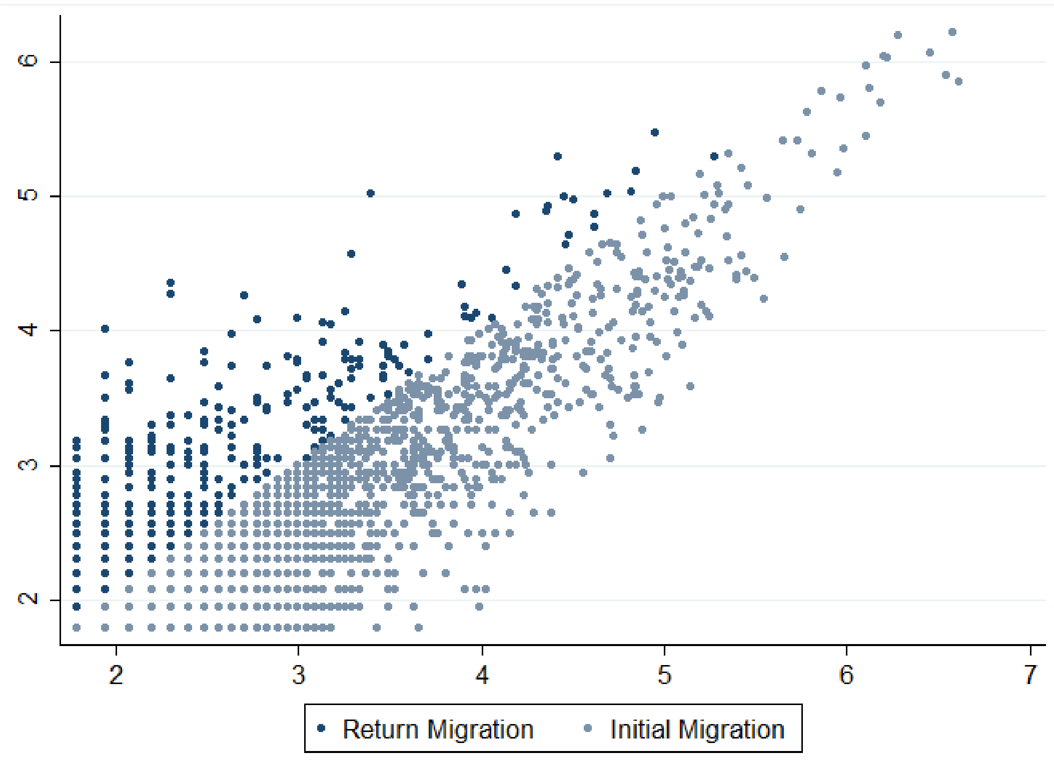
[7]We deal with top-coded income data (roughly 5% of the observations) by applying the imputation procedure recently proposed by Card, Heining, and Kline (2013).

cated, followed by the permanent and the return migrants. The share of unemployed workers is higher among the movers (and in particular among the repeated migrants), indicating that job loss may be a major cause for migration at any stage.

2.2 Two-way Return Migration

In the following we document the pattern of initial and later return migration between 96 German regions over the time span from 1990 to 2014. As illustrated in Figure 1 we find that initial and later return migrants often move into opposite directions. In Figure 1 each obser-

Figure 1: *Balance in Initial and Return Migration*



vation represents a combination of logarithmic immigration and emigration flows between a certain pair of regions.[8] Initial migration flows thereby are ordered in such a way that the larger of the two migration flows is measured along the abscissa, whereas return migration flows are ranked such that the larger of the two return migration flows is depicted along the ordinate. As consequence, all initial migration flows appear below the 45°-line, while the

[8]Following the IAB's data protection guidelines we are only allowed to report flows that consists of more then five migrants.

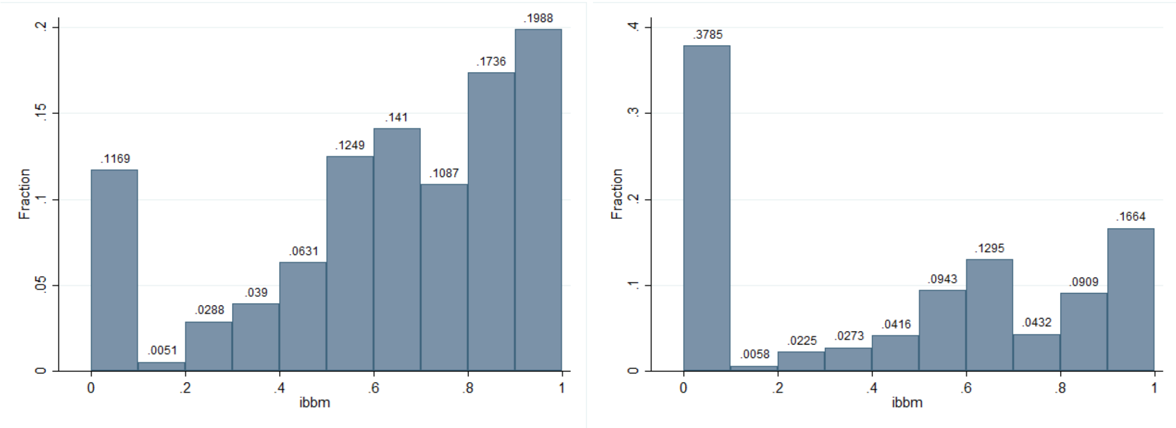
return migration flows are reported above the 45°-line. The 45°-line thereby represents a natural benchmark for perfectly balanced (return) migration flows, with observation that are further away from the 45°-line being more unbalanced. According to Figure 1 we find initial and later return migration to be rather balanced, with the major difference that there are fewer return migrants than initial migrants.

As a major drawback of Figure 1, we cannot observe highly, or even perfectly unbalanced migration flows. In order to quantify the balance in regional return migration we therefore follow Biswas and McHardy (2005) and Kreickemeier and Wrona (2017) and compute the share of bilateral (return) migration between region pair (x, y) that can be characterised as two-way, using an Index of Bilateral Balance in Migration $IBBM_{xy} = 2min\{M_{xy}, M_{yx}\}/(M_{xy}+M_{yx}) \in [0, 1]$, in which $M_{xy} \geq 0$ represents the flow of migrants from region x to region y.[9] By construction the index takes a value of one, if migration is perfectly balanced (i.e. $M_{xy} = M_{yx}$) and a value of zero if migration is completely unbalanced (i.e. either $M_{xy} = 0$ or $M_{yx} = 0$). In order to compute the Index of Bilateral Balance in Migration, we require non-zero migration in at least one direction, which is the case for $4,482$ of the potential $96 \times 95 = 9,120$ region pairs.

In Figure 2 we depict the distribution of IBBMs for initial and later return migration. In terms of initial migration (see Figure 2a) most region pairs are characterised by an IBBM that takes an value that is larger than 0.5, with the most frequent observation being a value in the vicinity of one. For 523 region pairs we find initial migration to be perfectly unbalanced, which may at least partly be explained by the fact that these region pairs are generally characterised by low migration flows (e.g. due to their small population sizes or their large bilateral distance). For return migration a similar pattern arises (see Figure 2b), although the share of perfectly unbalanced return migration flows is considerably higher. The high share of perfectly unbalanced return migration flows thereby arises mechanically due to the small-sample properties of the IBBM, which more often takes extreme values because the number of return migrants is much smaller than the total number of (initial) migrants.

[9] The definition of the Index of Bilateral Balance in Migration (IBBM) is directly analogous to the well-known Grubel-Lloyd index (cf. Grubel and G.Lloyd, 1975) measuring the extent of intra-industry trade, that is two-way trade in goods within the same industry (see Brülhart, 2009, for a recent application).

Figure 2: *Distribution of IBBMs for Initial and Return Migration*



(a) *IBBMs for Initial Migration* **(b)** *IBBMs for Return Migration*

2.3 Selection into Planned Return Migration

Is there supportive evidence for a systematic selection into planned return migration? To answer this question we analyse the selection into different migration modes (permanent, return, onward and no migration) based on individuals' initial migration decisions. When migration is planned to be temporary, we would expect initial migrants to differ depending on their prospects of migrating either temporary or permanently. On the contrary, if return migration results from the revision of an initial migration decision in response to an unanticipated income shock *ex post* to the initial migration decision (as for example in De la Roca, 2017), we would not expect to find differences between initial migrants conditional on their later migration experiences.

In search for systematic differences among initial migrants (conditional on their later return decisions), we follow De la Roca (2017), and run a multinomial logit regression, which allows for four different outcomes: no migration, permanent migration, return migration and onward migration (with no migration as the baseline category). We use lagged logarithmic wages as a comprehensive measure of all observable and unobservable income determinants, and control for an extensive set of time-varying observable individual characteristics (experience, firm tenure, age, and some further employment characteristics) as well as for several constant individual characteristics (education, gender and, home region). To capture a general time trend we include the complete set of year dummies up to the last possible migration year.

Table 2: *Selection into Different Types of Migration Based on Initial Wages*

Multinominal Logit for Selection into Different Types of Migration (No, Permanent, Return, Onward) Based on Initial Wages												
Type of Regions:	**All Regions**						**Only Urban**					
East vs. West Germany:	**East & West**			**Only West**			**East & West**			**Only West**		
Migration Type:	**Permanent**	**Return**	**Onward**	**Permanent**	**Return**	**Onward**	**Permanent**	**Return**	**Onward**	**Permanent**	**Return**	**Onward**
Specification:		**(1)**			**(2)**			**(3)**			**(4)**	
Lagged logarithmic wage	1.091***	1.071***	1.103***	1.096***	1.061***	1.095***	1.212***	1.113***	1.206***	1.204***	1.119***	1.212***
	(13.49)	(6.71)	(5.98)	(13.32)	(5.59)	(5.32)	(15.86)	(6.97)	(7.39)	(14.94)	(7.11)	(7.41)
Education:												
vocational training	1.184***	2.315***	2.231***	1.159***	2.185***	2.277***	0.985	2.202***	1.755***	0.975	2.142***	1.760***
	(8.52)	(18.90)	(10.26)	(6.84)	(16.86)	(9.40)	(-0.43)	(12.42)	(5.06)	(-0.71)	(11.83)	(4.94)
some college	1.917***	4.021***	4.797***	2.054***	4.079***	5.356***	1.847***	3.758***	4.019***	1.881***	3.771***	4.056***
	(23.90)	(26.97)	(17.64)	(24.37)	(26.03)	(16.98)	(13.13)	(17.85)	(10.80)	(13.23)	(17.68)	(10.54)
university	3.711***	5.635***	11.39***	4.075***	5.831***	13.34***	3.634***	5.523***	10.03***	3.746***	5.536***	10.43***
	(63.18)	(37.86)	(30.77)	(62.70)	(37.08)	(29.37)	(36.39)	(26.34)	(20.59)	(36.45)	(26.07)	(20.34)
Employment Status:												
part-time	0.811***	0.802***	0.876***	0.792***	0.750***	0.851***	0.834***	0.793***	0.968	0.828***	0.788***	0.967
	(-14.62)	(-9.25)	(-3.49)	(-14.59)	(-10.96)	(-3.90)	(-7.08)	(-6.60)	(-0.58)	(-7.11)	(-6.59)	(-0.58)
public	0.736***	0.743***	0.582***	0.739***	0.758***	0.572***	0.693***	0.697***	0.531***	0.704***	0.683***	0.533***
	(-14.52)	(-8.92)	(-9.15)	(-12.43)	(-7.55)	(-8.19)	(-9.28)	(-7.07)	(-6.48)	(-8.61)	(-7.15)	(-6.20)
unemployed	4.118***	3.084***	3.699***	4.286***	3.167***	3.807***	4.052***	2.951***	3.874***	4.078***	2.992***	3.929***
	(103.88)	(50.50)	(39.40)	(97.29)	(48.45)	(37.00)	(57.42)	(32.19)	(26.90)	(56.03)	(31.94)	(26.51)
training	1.694***	1.422***	1.813***	1.587***	1.379***	1.730***	1.683***	1.335***	1.648***	1.644***	1.299***	1.645***
	(35.76)	(15.45)	(17.37)	(29.92)	(13.75)	(15.44)	(18.73)	(8.04)	(8.96)	(17.30)	(7.02)	(8.68)
Experience:												
experience	1.014***	1.026***	1.019***	1.008***	1.023***	1.014***	1.013***	1.026***	1.017***	1.011***	1.025***	1.016***
	(24.79)	(35.20)	(15.45)	(14.39)	(30.39)	(11.01)	(12.89)	(23.77)	(9.24)	(11.18)	(22.84)	(8.23)
tenure	0.779***	0.805***	0.741***	0.785***	0.810***	0.743***	0.784***	0.808***	0.749***	0.787***	0.809***	0.751***
	(-120.11)	(-72.98)	(-55.21)	(-104.31)	(-65.69)	(-48.82)	(-63.70)	(-48.48)	(-33.42)	(-60.77)	(-46.78)	(-31.83)
Gender:												
female	1.069***	0.930***	0.857***	1.117***	0.995	0.925***	1.086***	0.941***	0.879***	1.092***	0.960**	0.891***
	(8.40)	(-5.89)	(-7.65)	(12.40)	(-0.37)	(-3.50)	(5.63)	(-3.25)	(-4.05)	(5.84)	(-2.13)	(-3.51)
N	11391995			9968341			5247062			5017193		
Pseudo R2	0.118			0.114			0.111			0.111		

Notes: All specification show a multinomial logit regression model with dummies for year, age and initial region. The baseline category is non-migration. The urban-to-urban specification shows workers in initially urban regions that move to other urban regions, initially rural workers and movers to rural areas are excluded. If indicated, the sample is reduced to initially west German regions. Robust standard errors are computed. Exponentiated coefficients; t-statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In Table (2) we report the regression results, comparing non-migrants (baseline category) to the different migrant types (permanent, return, and onward migrants) prior to their initial migration decision. Our preferred Specification (1) covers the complete sample of 96 German regions. In Specification (2) we then focus only on West-German regions, which we also observe prior to the German reunification. In the Specifications (3) and (4) we use a reduced and therefore less heterogeneous sample of 24 urban regions to repeat the exercise.

Throughout, we find that all migrant types are positively selected in terms of their pre-migration income. Apart from the overall effect we find that there are systematic differences among the different groups of migrants. Return migrants are less positively selected than comparable permanent or onward migrants. We interpret this differential selection into initial migration as indirect evidence in favour of planned return migration between regions that are not characterised by strong institutional differences.

Although not the focus of this study, it is noteworthy that our results from Table 2 are generally in line with previous findings in the regional migration literature (cf. Hunt, 2004; De la Roca, 2017). In particular, we find that higher educational attainment is positively related to the probability of migrating. The positive selection based on worker's observable skills thereby is more pronounced for return migrants than for permanent migrants, which suggests that there is a difference between the selection based on observable and unobservable skills, as captured by individual pre-migration wages.

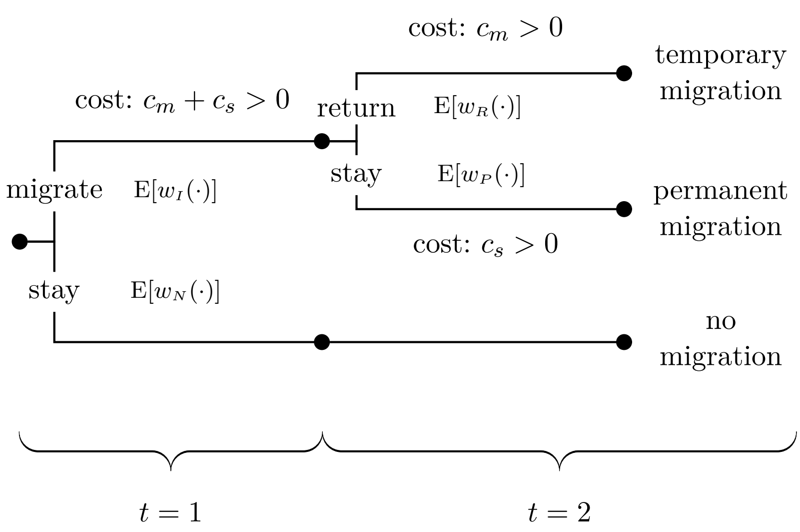
3 A Simple Model of Planned Return Migration

Having established empirical evidence in favour of planned return migration between similar regions, we now develop a simple model to rationalise this finding. We thereby proceed as follows: In Subsection 3.1 we lay out workers' inter-temporal migration decision. Subsection 3.2 then describes the hiring process and determines the wages on which workers base their migration decisions. Finally, in Subsection 3.3 we jointly derive the selection of workers into initial and return migration.

3.1 Return Migration Decision

We illustrate individual migration decisions in Figure 3. Workers are forward looking and

Figure 3: *Migration and Return Decisions*



base their migration decisions on the expected wages E$[w_i(\cdot)]$ that they anticipate to earn in response to their mobility choice. Confronted with one-time moving costs $c_m \geq 0$ as well as periodical staying cost $c_s \geq 0$ workers in period one can decide whether to migrate or to stay. Those workers, who initially migrated, then can decide in period two whether to return or to stay permanently. As a consequence, we can distinguish between four different types of workers, to which we refer as non-migrants (indexed by subscript $i = N$), initial migrants (indexed by subscript $i = I$), return migrants (indexed by subscripts $i = R$), and permanent migrants (indexed by subscript $i = P$).

3.2 Hiring and Wage Setting

We focus on two symmetric regions, each producing a non-storable, homogeneous *numraire* good, that can be costlessly traded at a normalised price $p \stackrel{!}{=} 1$.[10] Both regions are populated by two overlapping generations of risk-neutral workers, whose privately known skills s are uniformly distributed over the unit interval $s \in [0, 1]$. The production of the homogeneous *numéraire* good is modelled through an "O-ring" production technology (cf. Kremer, 1993), which requires the processing of two tasks $l = 1, 2$, each to be performed by a single worker.[11] Firm-level output then follows as:

$$y = f(s_1, s_2) = 2As_1s_2, \tag{1}$$

with $A > 0$ being a technology parameter and s_l denoting the skill level of the worker performing task $l = 1, 2$. Crucially, we have $\partial f(s_1, s_2)/\partial s_l > 0$ and $\partial^2 f(s_1, s_2)/\partial s_l \partial s_\ell > 0 \ \forall \ l, \ell = 1, 2$ with $l \neq \ell$, such that the technology in Eq. (1) is supermodular and workers enter production as complements (see also Milgrom and Roberts (1990) and Topkis (1998)).

Firms can not observe workers' skills, which are private information. Yet, in an equilibrium, that features some form of migration as described in Figure 3, firms can easily identify individual workers according to their (observable) type $i \in \{N, I, R, P\}$. This is the only information firms can base their hiring decision on, and this information is valuable since, as we show below, the average skills within these four sub-groups of workers are different. Taking into account these differences, firms maximise their expected profits by choosing the

[10]Given that regions are symmetric, region-specific indices are dropped in order to save on notation.

[11]For anecdotal evidence on the general importance of complementaries in team production see Kremer (1993), who also discusses the eponymous example of a single malfunctioning O-ring causing the 1986 Challenger shuttle disaster. Theoretical applications of Kremer's (1993) O-ring theory include Dalmazzo (2002), Pekkarinen (2002), Fabel (2004), Dalmazzo, Pekkarinen, and Scaramozzino (2007), Jones (2011) as well as Kreickemeier and Wrona (2017).

optimal skill mix of their employees:

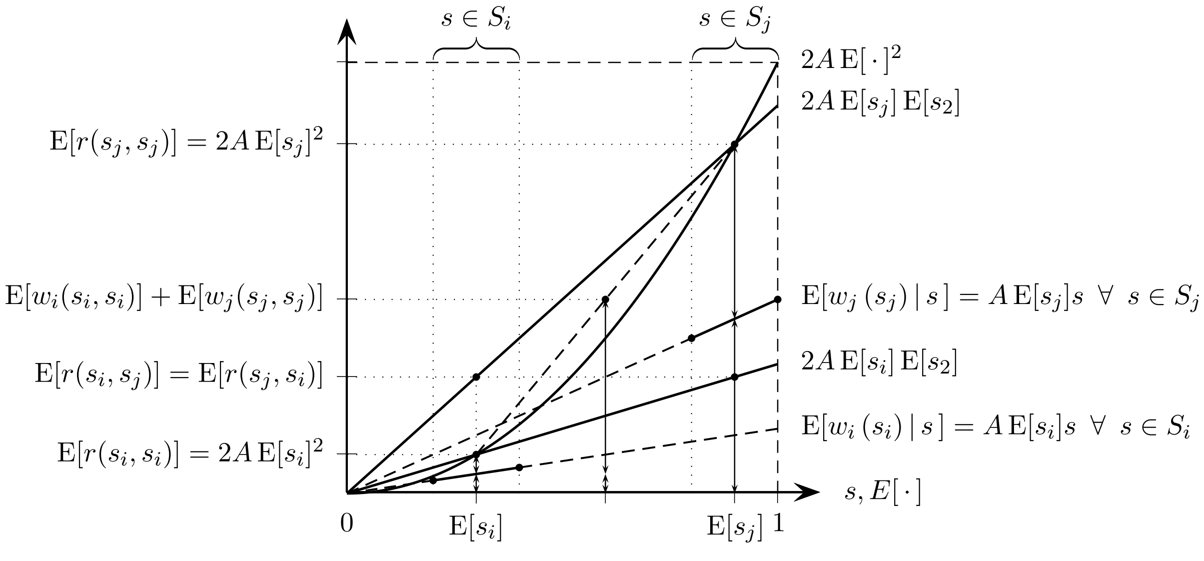
$$\max_{s_1,s_2} \; \mathrm{E}[\pi\,(s_1,s_2)] = 2A\,\mathrm{E}[s_1]\,\mathrm{E}[s_2] - \mathrm{E}[w_1\,(s_1,s_2)] - \mathrm{E}[w_2\,(s_1,s_2)], \tag{2}$$

with $\mathrm{E}[s_l]$, $l = 1, 2$ referring to the expected skill of the group from which the worker performing task l is recruited, and $\mathrm{E}[w_l(s_l, s_\ell)]$ $\forall$ $l, \ell = 1, 2$ with $l \neq \ell$ being the wage that in expectation has to be paid to this worker.

To rationalise the firm's profit-maximising choice of co-hiring only workers, which in expectation have the same skill, consider the following proof by contradiction. Firms have two basic options of hiring workers: They either hire only workers of the same type, which in expectation have the same skill (i.e. $\mathrm{E}[s_l] = \mathrm{E}[s_i]$ $\forall$ $l = 1, 2$), or they co-hire workers of different types, who differ in terms of their expected skills (i.e. $\mathrm{E}[s_l] = \mathrm{E}[s_i]$ and $\mathrm{E}[s_\ell] = \mathrm{E}[s_j]$ with $l \neq \ell$ and $i \neq j$). In the following it is established that firms, which practice cross-hiring, are outcompeted under perfect competition and free market entry.

Figure 4 illustrates a firm's hiring decision for two arbitrary chosen sub-sets of workers (S_i and S_j). Suppose firms hires only workers with the same expected skill (i.e. $\mathrm{E}[s_i]$ or

Figure 4: *Hiring Strategies and Wage Formation*



$\mathrm{E}[s_j]$). Expected revenues are then given by the simple quadratic expressions $2A\,\mathrm{E}[s_i]^2$ and $2A\,\mathrm{E}[s_j]^2$, whose values can be read off from the ordinate of Figure 4. Wages can not be set according to individual skill, which is private information. We therefore assume that in a zero-profit equilibrium with free market entry each worker is paid exactly half of the firm's revenue, which leads to $\mathrm{E}[r(s_i, s_i)] = 2\,\mathrm{E}[w_i(s_i, s_i)]$ and $\mathrm{E}[r(s_j, s_j)] = 2\,\mathrm{E}[w_j(s_j, s_j)]$ (expected wages payments to each worker are illustrated in Figure 4 through the length of the equally sized arrows summing up to $\mathrm{E}[r(s_i, s_i)]$ and $\mathrm{E}[r(s_j, s_j)]$, respectively). Now suppose firms hire workers, who differ in terms of their skills. If the first task is performed by a worker with expected skill $\mathrm{E}[s_i]$, the firm's expected revenue can be expressed as a linear function with slope $2A\,\mathrm{E}[s_i]$, which is increasing in the expected skill $\mathrm{E}[s_2]$ of the worker that is chosen to perform the second task. Evaluating this function at $\mathrm{E}[s_2] = \mathrm{E}[s_j]$ yields $\mathrm{E}[r(s_i, s_j)] = \mathrm{E}[r(s_j, s_i)] = 2A\,\mathrm{E}[s_i]\,\mathrm{E}[s_j]$ as illustrated in Figure 4. Finally, to establish that firms, who cross-hire workers from different groups, expect to make losses we acknowledge that in a competitive labour market cross-hiring firms have to offer (at least) $\mathrm{E}[w_i(s_i, s_i)]$ and $\mathrm{E}[w_j(s_j, s_j)]$, summing up to an expected wage bill of $\mathrm{E}[w_i(s_i, s_i)] + \mathrm{E}[w_j(s_j, s_j)]$. As illustrated in Figure 4, this expected wage bill can be computed as a simple linear combination:

$$\mathrm{E}[w_i(s_i, s_i)] + \mathrm{E}[w_j(s_j, s_j)] = \tfrac{1}{2}\left\{\mathrm{E}[r(s_i, s_i)] + \mathrm{E}[r(s_j, s_j)]\right\} = A\,\mathrm{E}[s_i]^2 + A\,\mathrm{E}[s_i]^2,$$

given that $\mathrm{E}[w_i(s_i, s_i)] = \frac{1}{2}\,\mathrm{E}[r(s_i, s_i)] = A\,\mathrm{E}[s_i]^2$ and $\mathrm{E}[w_j(s_j, s_j)] = \frac{1}{2}\,\mathrm{E}[r(s_j, s_j)] = A\,\mathrm{E}[s_i]^2$. Since it is now easily demonstrated that the expected profits of a cross-hiring firm are negative, i.e. $\mathrm{E}[\pi(s_i, s_j)] = \mathrm{E}[r(s_i, s_j)] - \mathrm{E}[w_i(s_i, s_i)] - \mathrm{E}[w_j(s_j, s_j)] = -2A(\mathrm{E}[s_i] - \mathrm{E}[s_j])^2 < 0$ (see also Figure 4), we can conclude that workers, who differ in terms of their expected skills, should never be co-hired.

To understand why cross-hiring is a suboptimal strategy we first consider the natural benchmark in which workers' skills are perfectly observable. As demonstrated by Kremer (1993) profits under perfect information are maximised through positive assortative matching, which we illustrate by means of the following simple example: Suppose workers' skills are equally likely to take values of $s = 0$ and $s = 1$. Under random matching there are four equally likely pairings: $(0, 0)$, $(0, 1)$, $(1, 0)$, and $(1, 1)$. Obviously, the parings $(0, 1)$ and $(1, 0)$ are highly inefficient. Unskilled co-workers with $s = 0$ create a bottleneck, which completely invalidates the otherwise valuable input of the skilled workers. As a consequence firm-level production is zero in three out of four instances, which results in an expected revenue of just one fourth. Under positive assortative matching the only remaining pairings are $(0, 0)$ and $(1, 1)$. Firms, that solely hire skilled workers thereby create a revenue of one, and therefore can always afford to outcompete cross-hiring firms by paying higher wages. Now, if skills are private information, firms are forced to match their workers randomly, resulting in an efficiency loss as highlighted above. Any information that correlates with workers' skill therefore is highly valuable as it can be used to refine firms' hiring strategy towards the optimal positive assortative matching. By classifying workers into informative sub-groups, which differ in terms of their expected skill, firms can reduce the likelihood of an inefficient missmatch relative to the first-best hiring strategy of positive assortative matching by combining only workers which in expectation have the same skill.

Given the deliberately simple hiring rule of combining only workers with identical expected skills, we can now turn to the expectations that workers have with regard to their own wages. Consider a worker from group i with skill $s \in S_i$, which is privately known by the worker. Anticipating a co-worker with expected skill $\mathrm{E}[s_i]$ this worker expects to earn a wage:

$$\mathrm{E}[w_i\,(s_i)\,|\,s_i] = A\,\mathrm{E}[s_i]s \;\;\forall\;\; s \in S_i \;\;\text{with}\;\; i \in \{N, I, R, P\}, \tag{3}$$

conditional on knowing his own skill s. Given the worker's skill s the expected wage is linearly increasing in group i's expected skill level $\mathrm{E}[s_i]$ (see also Figure 4). With this simple notion of workers' wages at hand, the (return) migration decision of a forward-looking worker can now be solved through backward induction following the structure that has been imposed in Figure 3.

3.3 Selection into Return Migration

Following the recursive structure of Figure 3 we focus at workers' return decision in period two (implicitly assuming that these workers migrated in period one). We define the expected wage gain that workers give up when returning home in period two as:

$$\Delta_2^w\,(s) \equiv \mathrm{E}[w_P\,(s_P)\,|\,s\,] - \mathrm{E}[w_R\,(s_R)\,|\,s\,]. \tag{4}$$

Thereby, $\mathrm{E}[w_P\,(s_P)\,|\,s\,]$ and $\mathrm{E}[w_R\,(s_R)\,|\,s\,]$ denote the wage that workers (conditional on their skill s) expect to earn as permanent and return migrants, respectively. In order to replicate the negative self-selection of workers into return migration, that we have documented in Section 2.3, we assume that the periodical cost of staying away from home c_s exceed the one-time moving cost c_m, which can be further simplified into $c_s > c > c_m = 0$.

Focussing on positively selected initial migrants, whose skill s lies above the initial migration cutoff $\tilde{s}_m$, we can determine the return cutoff $\tilde{s}_r$, that separates the less skilled return migrants (indexed by subscript R) from the relatively more skilled permanent migrants (indexed by subscript P). The expected skills of both sub-groups thereby follow immediately from the assumed uniform distribution and equal $\mathrm{E}[s_P] = E[\, s \,|\, s \geq \tilde{s}_r] = (\tilde{s}_r + 1)/2 > \mathrm{E}[s_R] = E[\, s \,|\, \tilde{s}_m > s \geq \tilde{s}_m] = (\tilde{s}_m + \tilde{s}_r)/2$. We can now substitute $\mathrm{E}[s_P]$ and $\mathrm{E}[s_R]$ into the expected wage rate from Eq. (3), which in return can be used to replace $\mathrm{E}[w_P\,(s_P)\,|\, s\,]$ and $\mathrm{E}[w_R\,(s_R)\,|\, s\,]$ in Eq. (4). The expected wage gain from permanent migration then equals $\Delta_2^w\,(s) = A(1-\tilde{s}_m)s/2$, which is increasing in individual skill s, such that incentives for staying (returning) are highest for those migrants with comparatively high (low) skills. The indifferent return migrant:

$$\tilde{s}_r\,(\tilde{s}_m) = \frac{2\hat{c}}{1-\tilde{s}_m} \tag{5}$$

can therefore be found by equating the wage gain from permanent migration with the corresponding costs, i.e. $\Delta_2^w\,(\tilde{s}_r) \stackrel{!}{=} c$. Of course permanent migration is more pronounced if the associated costs $\hat{c} \equiv c/A$ are low. However, due to the recursive structure of the migration decision (cf. Figure 3) these costs must be weighted by the potential for permanent migration, i.e. the mass of workers $1 - \tilde{s}_m$, who decided to migrate in the first period.

To understand the negative selection into return migration it is helpful to revisit the formulation of workers' wages in Eq. (3). As firms prefer to match workers with the same expected skill, there is a monetary benefit from being associated with a group of high-skilled rather than low-skilled co-workers. However, the expected wage gain $\Delta_2^w\,(s)$ from being paired with on average more high-skilled co-workers is non-constant and increases linearly in the respective worker's own skill s. Hence, if a worker's status as permanent migrant is both costly and easy to verify, only workers with sufficiently high skills will use permanent migration as an (imperfect) signal to indicate their comparatively high but otherwise unobservable skills. Firms take into account individual migration histories as an easy-to-verify signal, and form more efficient and better-paid matches, which provide workers with an incentive to signal their skills in the first place.

Having established and explained the negative selection into return migration (conditional on positive selection into initial migration), we now complete our model by turning to workers' initial migration decision in period one. Anticipating their later return decision in period two, workers distinguish three possible migration patterns, to which we refer as:

(a) $0 < \tilde{s}_m < \tilde{s}_r < 1 \quad \Rightarrow \quad$ *temporary and permanent migration,*

(b) $0 < \tilde{s}_m < \tilde{s}_r = 1 \quad \Rightarrow \quad$ *temporary migration only,*

(c) $0 = \tilde{s}_m = \tilde{s}_r < 1 \quad \Rightarrow \quad$ *no migration.*

According to pattern (a) only the best workers with skills $s \in [\tilde{s}_r, 1]$ stay for another period at cost $c > 0$. Workers with lower skills $s \in [\tilde{s}_m, \tilde{s}_r)$ return home in period two. Pattern (b) with $\tilde{s}_r = 1$ implies that everybody, who migrated in period one, returns home in period two. Finally, there also is the trivial pattern (c) with no migration taking place at all.[12]

Knowing that the least skilled initial migrant $\tilde{s}_m$ will never migrate permanently, we derive the expected lifetime wage gain from temporary migration in period one as:

$$\Delta_1^w(s) \equiv \mathrm{E}[w_I(s_I) \,|\, s\,] + \mathrm{E}[w_R(s_R) \,|\, s\,] - 2\,\mathrm{E}[w_N(s_N) \,|\, s\,]. \tag{6}$$

Intuitively, $\Delta_1^w(s)$ depends negatively on the opportunity cost of migrating, which materialise in form of the forfeit income stream $2\,\mathrm{E}[w_N(s_N) \,|\, s\,]$, that would result from employment as a non-migrant (indexed by subscript N) in period one and two. On the plus side, there are the expected wage gains $\mathrm{E}[w_I(s_I) \,|\, s\,]$ of temporary migrating in period one in addition to $\mathrm{E}[w_R(s_R) \,|\, s\,]$, which is what the initial migrants expect to earn as returnees in period two. If pattern (a) with $0 < \tilde{s}_m < \tilde{s}_r < 1$ applies, only the best workers with $s \in [\tilde{s}_r, 1]$ stay permanently, while the remaining workers $s \in [\tilde{s}_m, \tilde{s}_r)$, and in particular the indifferent migrant $\tilde{s}_m$, return home to get employed at an expected wage $\mathrm{E}[w_R(s_R) \,|\, s\,]$. However, if pattern (b) applies, everybody including the indifferent migrant returns home and earns an expected wage rate of $\mathrm{E}[w_P(s_P) \,|\, s\,]$. Accounting for this difference, we can compute the

[12] In a Technical Supplement, which is available from the authors upon request, we show that an equilibrium with $\tilde{s}_m = \tilde{s}_r$, in which the migration and the return cut-off are the same, does not exist. In such an equilibrium, all workers, who migrated in period one, would stay in period two, which can not be optimal for the initially indifferent migrant $\tilde{s}_m$ as long as costs c are non-decreasing in the duration of staying away from home.

expected skills of all sub-groups $i \in \{N, I, R, P\}$ as:

$$\begin{aligned} &\mathrm{E}[s_P] = (\tilde{s}_r + 1)/2 > \mathrm{E}[s_I] = (\tilde{s}_m + 1)/2 > \mathrm{E}[s_R] = (\tilde{s}_m + \tilde{s}_r)/2 > \mathrm{E}[s_N] = \tilde{s}_m/2 \;\text{ if } (a), \\ &\mathrm{E}[s_I] = \mathrm{E}[s_R] = (\tilde{s}_m + 1)/2 > \mathrm{E}[s_N] = \tilde{s}_m/2 \;\text{ if } (b). \end{aligned} \tag{7}$$

We then substitute the expected skills $\mathrm{E}[s_i]$ from Eq. (7) into the expected wage rates $\mathrm{E}[w_i(s_i) \mid s_i]$ from Eq. (3), which in return can be used to solve the expected lifetime wage gain from temporary migration in Eq. (6) as:

$$\Delta_1^w(s) = \begin{cases} A(1 + \tilde{s}_r)\, s/2 & \text{for } (a), \\ As & \text{for } (b). \end{cases} \tag{8}$$

The lifetime wage gain from temporary migration is strictly increasing in the migrant's skill s. Provided that there is a negative selection into return migration (i.e. pattern (a) applies), $\Delta_1^w(s)$ also increases in the return cutoff $\tilde{s}_r$. Intuitively, workers are forward looking, and therefore anticipate their later return decision (reflected by the return cut off $\tilde{s}_r$) when forming their initial migration decision. A higher return cut-off $\tilde{s}_r$ increases the expected skills $\mathrm{E}[s_R] = \mathrm{E}[\, s \mid \tilde{s}_m \leq s < \tilde{s}_r] = (\tilde{s}_m + \tilde{s}_r)/2$ within the groups of returnees, which makes temporary migration – *ceteris paribus* – more attractive.

We can use the previously derived return cutoff from Eq. (5) in order to endogenise $\tilde{s}_r$ in Eq. (8). The migration cutoffs:

$$\tilde{s}_m(\hat{c}) = \begin{cases} \dfrac{1 + 4\hat{c} - \sqrt{1 + 16\hat{c}^2}}{2} & \text{for} \quad 0 \leq \hat{c} < \dfrac{1}{3} \\ \hat{c} & \text{for} \quad \dfrac{1}{3} \leq \hat{c} < 1, \end{cases} \tag{9}$$

and

$$\tilde{s}_r(\hat{c}) = \begin{cases} \dfrac{4\hat{c}}{1 - 4\hat{c} + \sqrt{1 + 16\hat{c}^2}} & \text{for} \quad 0 \leq \hat{c} < \dfrac{1}{3}, \\ 1 & \text{for} \quad \dfrac{1}{3} \leq \hat{c} < 1, \end{cases} \tag{10}$$

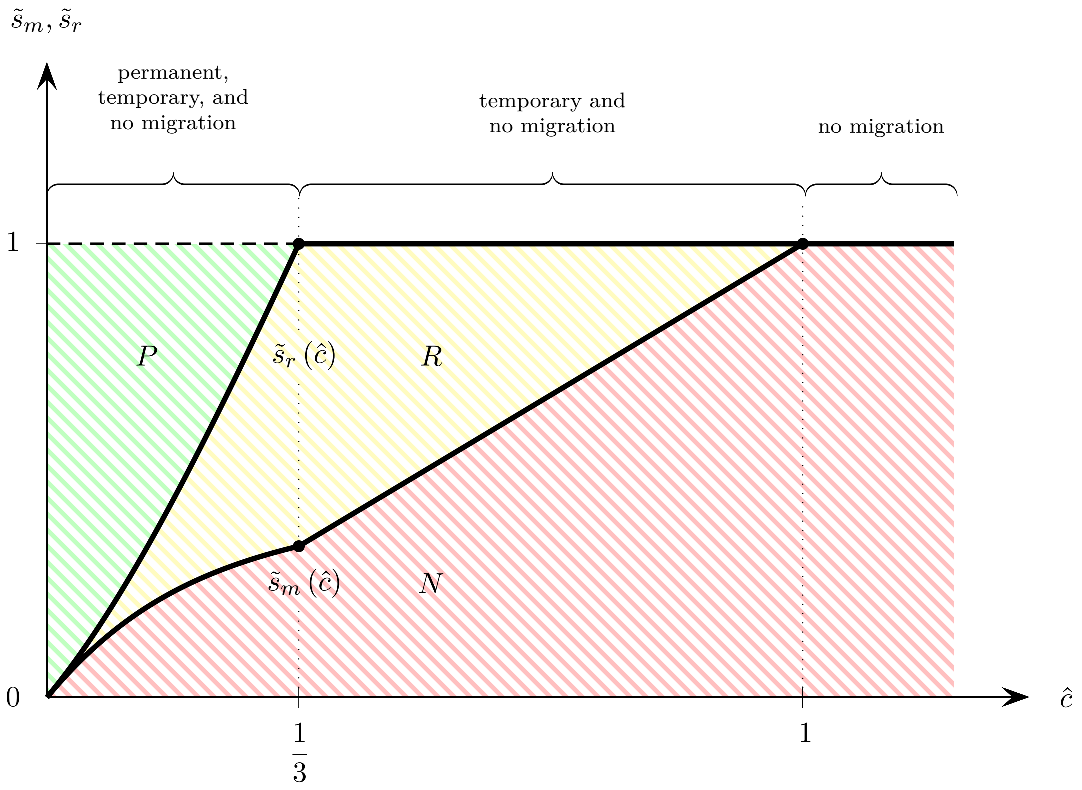
can then be solved by equating the expected lifetime income from temporary migration with the associated costs $\Delta_1^w(\tilde{s}_m) \overset{!}{=} c$ before substituting the solution for $\tilde{s}_m$ back into $\tilde{s}_r$ from Eq. (5).

Proposition 1 summarises our selection results, which we illustrate in Figure 5:

Proposition 1 *For sufficiently low but non-zero cost $\hat{c} \in (0, 1/3)$ high-skilled workers with $s \in [\tilde{s}_r, 1]$ migrate permanently, medium-skilled workers with $s \in [\tilde{s}_m, \tilde{s}_r)$ migrate temporary, and low-skilled workers $s \in [0, \tilde{s}_m)$ do not migrate at all.*

Proof Analysis and formal discussion in the text. ■

Figure 5: *Selection into Temporary and Permanent Migration*



The positive selection into initial migration as well as the negative selection into return migration both follow from the same intuition: costly stays away from home can be used to signal workers' high but otherwise unobservable skills. High-skilled workers with $s \in [\tilde{s}_m, 1]$ thereby use migration in period one as a signal to achieve a separation from their low-skilled counterparts with skills $s \in [0, \tilde{s}_m)$. In the second period medium-skilled workers with skill $s \in [\tilde{s}_m, \tilde{s}_r)$ return home, while the most high-skilled workers with skills $s \in [\tilde{s}_r, 1]$ stay for a second and final period to generate yet again a signal which allows future employers to tell apart the most high-skilled permanent migrants, which can afford to bear the signalling cost

$c > 0$ twice, from the medium-skilled returnees, which prefer the weaker signal associated with bearing the cost $c > 0$ only once.

Reassuringly, we find the selection pattern from Proposition 1, that we have illustrated in Figure 5, to be well in line with our empirical evidence from Section 2. As our model of planned return migration predicts, there is an *ex ante* negative selection into temporary migration. Notably, this result is derived in the absence of any systematic differences between regions. As consequences, initial and later return migration flows are expected to be perfectly balanced between both regions.

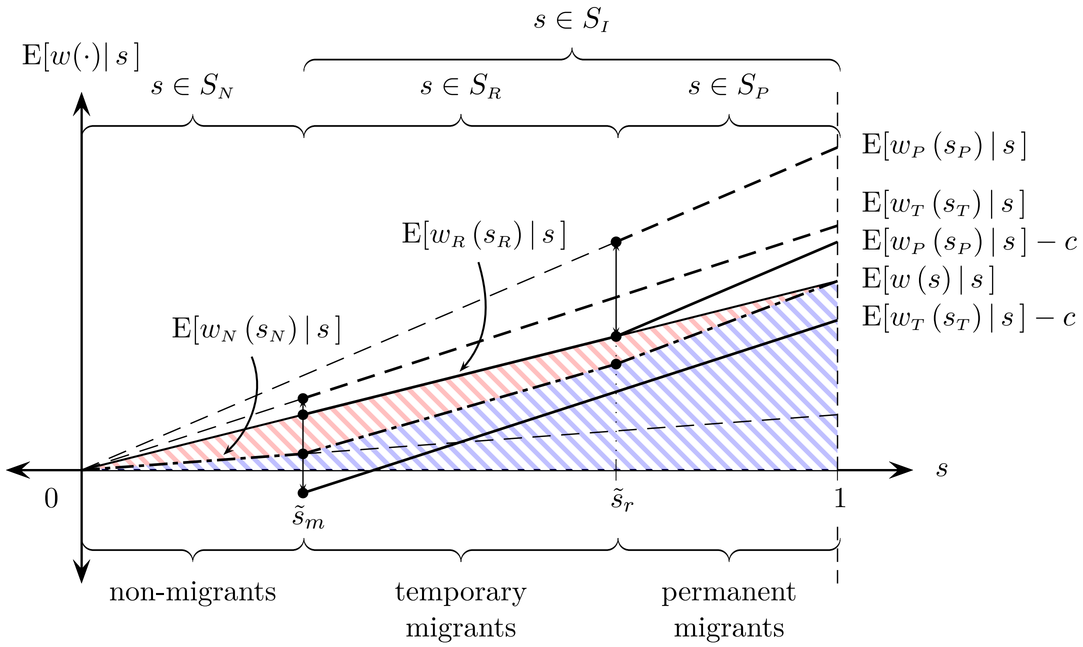
4 Welfare Implications and Optimal Policy

To characterise the model's wage and welfare results we proceed in three steps: Focussing on an equilibrium with negative selection into return migration, we demonstrate in Subsection 4.1 that there is an expected welfare loss relative to an equilibrium without migration. In Subsection 4.2 we then introduce an omniscient social planner to show that the laissez faire equilibrium is characterised by sub-optimally high levels of temporary and permanent migration. We conclude by deriving socially optimal migration policies mixes in Subsection 4.3.

4.1 Wages and Welfare

To characterise the individual wage and welfare effects across all four sub-groups $i \in \{N, I, R, P\}$, we focus again on the parameter range $\hat{c} \in (0, 1/3)$ for which the empirically relevant migration pattern (a) with negative selection into return migration applies. Figure 6 depicts the expected wage profiles for all four sub-groups (dashed lines), which we compare to the expected wage profile $\mathrm{E}[w(s)|\, s\,] = As/2$ in an equilibrium without any migration (solid line). From the ranking of expected skills in Eq. (7) we can infer that temporary and permanent migrants are both positively selected with respect to the overall population (i.e. $\mathrm{E}[s_P] > \mathrm{E}[s_I] > \mathrm{E}[\,s\,] = 1/2$), while the sub-group of non-migrants is negatively selected (i.e. $\mathrm{E}[s_N] < \mathrm{E}[\,s\,] = 1/2$). Temporary and permanent migrants therefore have steeper expected wage profiles, which means that both sub-groups enjoy higher wages than in an equilibrium without migration. The sub-group of non-migrants, which has lost its most high-skilled mem-

Figure 6: *Individual Wage and Welfare Effects*



bers through migration, is on average less skilled than in an equilibrium without migration, and therefore earns lower wages than in an equilibrium without migration. Since the sub-group of returnees is truncated from below (non-migrants) and above (permanent migrants), there is no clear ranking of the sub-group's expected skill $\mathrm{E}[s_R]$ relative to the expected skill $\mathrm{E}[\,s\,]$ in an equilibrium without migration. In Figure 6 we therefore focus on the knife-edge case $\mathrm{E}[s_R] = \mathrm{E}[\,s\,]$, which results under parameter constraint $\hat{c} = 1/4$, separating the the low cost scenario $\hat{c} < 1/4$ with negative selection (i.e. $\mathrm{E}[w_R(s_R)|\,s\,] < \mathrm{E}[w(s)|\,s\,]$) from the high cost scenario $\hat{c} > 1/4$ with positive selection (i.e. $\mathrm{E}[w_R(s_R)|\,s\,] > \mathrm{E}[w(s)|\,s\,]$).

To judge the impact of (return) migration on individual welfare we have to compute workers' expected lifetime income net of the periodical staying costs $c > 0$ (if applicable). The periodical net incomes of initial and permanent migrants in Figure 6 are depicted as parallelly downward shifted solid lines, which are drawn below the migrants' expected gross incomes $\mathrm{E}[w_I\,(s_I)\,|\,s\,]$ and $\mathrm{E}[w_P\,(s_P)\,|\,s\,]$, respectively. By averaging across both periods, we obtain workers' expected lifetime welfare, which we depict as dot-dashed line in Figure 6. Once the periodical costs of staying away from home are taken into account, we find that not only the non-migrants but also the temporary and the permanent migrants are worse off than in an equilibrium without migration. Proposition 2 generalises this surprising result beyond the illustrative knife-edge case ($\hat{c} = 1/4$), which we have covered in Figure 6.

Proposition 2 *Workers' expected lifetime welfare in an equilibrium with temporary and permanent migration is weakly lower than in an equilibrium without migration.*

Proof See Appendix A.1 $\blacksquare$.

While it is rather obvious that non-migrants suffer from the deterioration in the expected skill of their co-workers, it is less clear why the income-maximising temporary and permanent migrants turn out to be worse off than in an equilibrium without migration. To rationalise this puzzling result it is helpful to recall yet again the formulation of workers' wages in Eq. (3), which positively depend on the expected skill of the respective co-workers $E[s_i]$. The wages of all infra-marginal migrants thus depend on the critical migrant's mobility choice: By entering the group of infra-marginal migrants from below (i.e. with the lowest skill) the marginal migrant drags down the average skill within this group, thereby inflicting wage losses on all infra-marginal migrants. The critical worker rationally ignores this negative external effect on infra-marginal migrants, which results in suboptimally high levels of temporary and permanent migration (see also Subsection 4.2) and an expected welfare loss for (almost) all infra-marginal migrants.[13]

As an immediate implication of Proposition 2, according to which workers' expected welfare in a migration equilibrium is (weakly) lower than in an equilibrium without migration, it follows that regions expect aggregate welfare to be smaller than in an equilibrium without migration. To obtain expected welfare at the regional level, we compute at first expected output, which in a zero-profit equilibrium is defined as the sum of workers' expected wages:

$$\mathrm{E}[Y] = \int\limits_{s \in S_N} 2\,\mathrm{E}[w_N(s_N) \,|\, s]\, ds + \sum_i \int\limits_{s \in S_i} \mathrm{E}[w_i(s_i) \,|\, s]\, ds, \;\; \forall \;\, i \in \{I, R, P\}. \tag{11}$$

Using the definitions of $\mathrm{E}[w_i(s_i) \,|\, s]$ and $\mathrm{E}[s_i]$ from Eqs. (3) and (7) in combination with the

[13] For the most high-skilled workers with $s = 1$ expected welfare in an equilibrium with and without migration is the same.

migration and return cutoffs $\tilde{s}_m$ and $\tilde{s}_r$ from Eqs. (9) and (10) allows us to solve for:

$$\mathrm{E}[Y^{\mathrm{lf}}] = \begin{cases} \dfrac{A}{2} + A\,(1-2\hat{c})\,\hat{c} & \text{for} \quad 0 \leq \hat{c} < \dfrac{1}{3}, \\ \dfrac{A}{2} + A\,(1-\hat{c})\,\hat{c} & \text{for} \quad \dfrac{1}{3} \leq \hat{c} < 1 \end{cases} \tag{12}$$

where the superscript "lf" has been introduced to distinguish the *laissez faire* equilibrium from the social planner solution (indexed by superscript "sp"), which we will explore in more detail below. Clearly, expected regional output in any migration equilibrium is higher than $A/2$, which is the level of regional output that is expected in an equilibrium without migration. Regional output gains arise because firms use the information on workers' migration history to form more efficient worker matches within the various sub-groups $i \in \{N, I, R, P\}$. To compute expected welfare at the regional level the wasteful periodical staying costs $c > 0$ have to be subtracted from the value of expected regional output, which results in:

$$\mathrm{E}[\,W\,] = \mathrm{E}[\,Y\,] - (1-\tilde{s}_m)c - (1-\tilde{s}_r)c. \tag{13}$$

Substituting $\tilde{s}_m^{\mathrm{lf}}$ and $\tilde{s}_r^{\mathrm{lf}}$ from Eqs. (9) and (10) then allows us to solve for expected welfare at the regional level:

$$\mathrm{E}[\,W^{\mathrm{lf}}] = \begin{cases} \dfrac{A}{2} - A\,(1-2\hat{c})\,\hat{c} & \text{for} \quad 0 \leq \hat{c} < \dfrac{1}{3}, \\ \dfrac{A}{2} - A\,(1-\hat{c})\,\hat{c} & \text{for} \quad \dfrac{1}{3} \leq \hat{c} < 1, \end{cases} \tag{14}$$

which proves the following Corollary to Proposition 2:

Corollary 1 *Expected welfare at the regional level in an equilibrium with temporary and permanent migration is lower than in an equilibrium without migration.*

Proof Analysis and formal discussion in the text. ■

Figure 6 depicts aggregate welfare in an equilibrium with temporary and permanent migration as the blue area summing up workers' expected income net of the periodical staying cost c with loss in expected welfare relative to an equilibrium without migration being highlighted in red.

The expected welfare loss associated with temporary and permanent migration follows from a negative wage externality, which can be easily explained by means of a simple thought experiment: Suppose initial and permanent migration occur sequentially in decreasing order of migrants' skill. By deciding in favour of migration the respective critical workers inflict losses on all other workers. Non-migrants and return migrants loose because the expected skill within their sub-groups declines if the most high-skilled members of their sub-groups turn into initial or permanent migrants. At the same time, positively selected infra-marginal migrants suffer because the average skill within the sub-groups of initial and permanent migrants gets deteriorated through the entry of the relatively less skilled marginal migrants. The respective critical migrants rationally ignore these social costs, which results in excessive temporary and permanent migration in the *laissez faire* equilibrium. Thereby, the previously identified production gains, that arise from the more efficient matching of workers within their sub-groups, are more than offset by the wasteful migration costs $c > 0$, which are responsible for an expected welfare loss at the regional level.

4.2 Welfare Maximising Migration

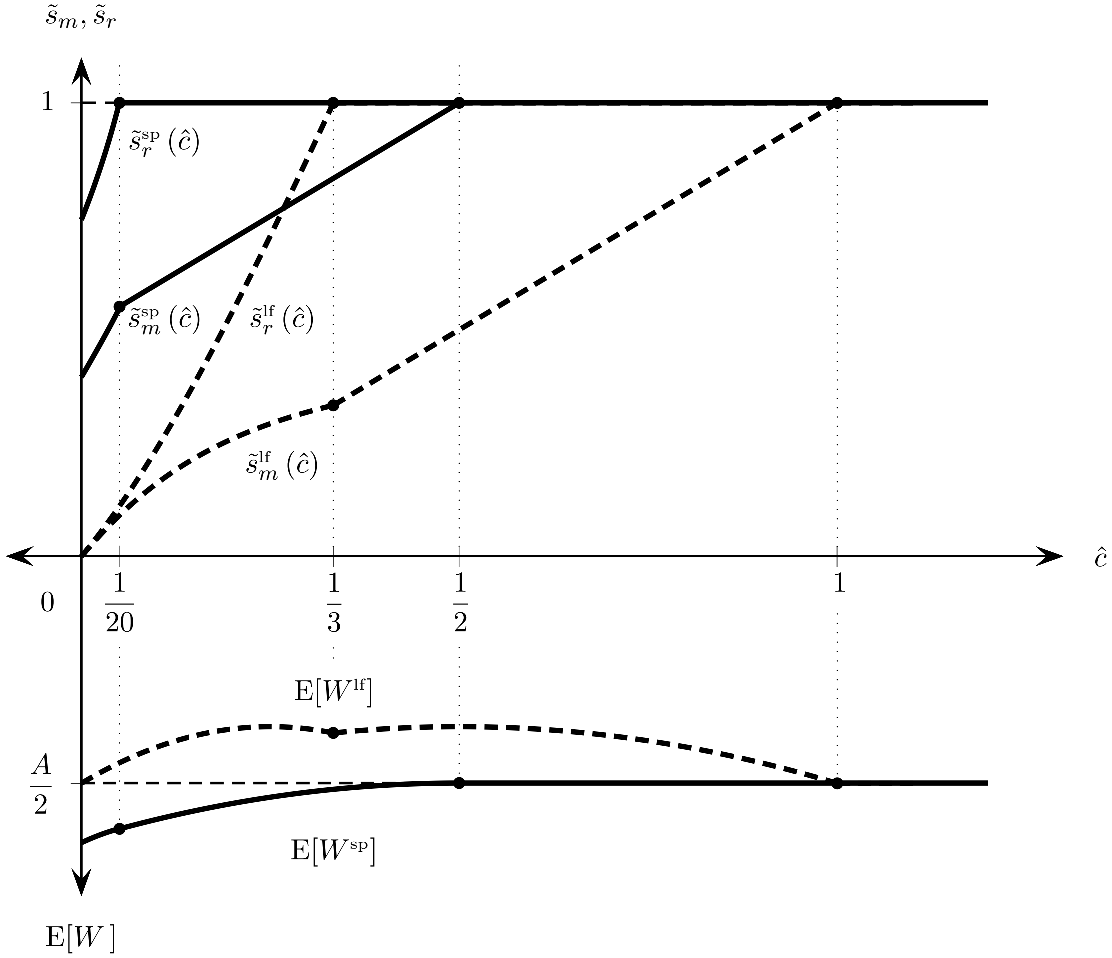
To demonstrate that the *laissez faire* equilibrium features suboptimally high levels of temporary and permanent migration we employ an omniscient social planner, who is constrained through firms' matching technology but otherwise can freely choose the migration and return cutoffs $\tilde{s}_m$ and $\tilde{s}_r$. The social planner thereby ignores individual (return) migration incentives which link $\tilde{s}_m^{\mathrm{lf}}$ and $\tilde{s}_r^{\mathrm{lf}}$ to $\hat{c} > 0$ in the *laissez-faire* equilibrium and maximises instead aggregate welfare in Eq. (13). We summarise the social planner solution in Proposition 3, and depict the socially optimal migration and return cutoffs, $\tilde{s}_m^{\mathrm{sp}}(\hat{c})$ and $\tilde{s}_r^{\mathrm{sp}}(\hat{c})$ together with the implied level of aggregate welfare $W^{\mathrm{sp}}(\hat{c})$ in Figure 7.

Proposition 3 *The laissez faire equilibrium features excessive temporary and permanent migration, which and is characterised by $\tilde{s}_m^{lf}(\hat{c}) < \tilde{s}_m^{sp}(\hat{c})$ and $\tilde{s}_r^{lf}(\hat{c}) < \tilde{s}_r^{sp}(\hat{c})$.*

Proof See Appendix A.2. ■

As evident from Figure 7 the socially optimal migration and return cutoffs $\tilde{s}_m^{\mathrm{sp}}(\hat{c})$ and $\tilde{s}_r^{\mathrm{sp}}(\hat{c})$ (solid curves) are strictly larger than their analogues $\tilde{s}_m^{\mathrm{lf}}(\hat{c})$ and $\tilde{s}_r^{\mathrm{lf}}(\hat{c})$ in the *laissez faire* equilibrium (dashed curves). The social planner thereby corrects for the presence of a negative external effect, that the marginal worker's migration decision has on the wages

Figure 7: *Social Planner Solution Versus Laissez Faire Equilibrium*



of all non-migrants as well as on the wage of all infra-marginal migrants. Interestingly, it is not in the social planner's interest to always enforces a zero-migration equilibrium. In particular at low costs $\hat{c}$ the aggregate production gains from improved matching exceed the social costs of (repeated) signalling. As a consequence migration pattern (a) with negative selection into return migration is implemented for sufficiently low costs $0 < \hat{c} \lesssim 1/20$, while the temporary-migration-only scenario (b) with $\tilde{s}_m^{\mathrm{sp}}(\hat{c}) = \frac{1}{2} + \tilde{s}_m^{\mathrm{lf}}(\hat{c})$ is chosen for high – but not prohibitively high – costs $1/20 \lesssim \hat{c} < 1/2$.[14] Intuitively, expected welfare $\mathrm{E}[W^{\mathrm{sp}}]$ in the social planner solution increase in rising levels of temporary and permanent migration as the cost c decline.

[14] Note that from the perspective of an omniscient social planner it is never optimal to implement an equilibrium that only features permanent migration, as the implied separation into a group of high-skilled permanent migrants and a group of low-skilled non-migrants could be more efficiently achieved in an equilibrium that features only temporary migration.

4.3 Optimal Migration Policies

Is it possible to implement the social planner's solution from Proposition 3 through a carefully chosen migration policy, which separately targets temporary and permanent migrants? To this end we introduce the two policy variables τ_m and τ_r, which shift the (periodical) costs $\hat{c}_1 = \hat{c} + \hat{\tau}_m$ and $\hat{c}_2 = \hat{c} + \hat{\tau}_r$ with $\hat{\tau}_k \equiv \tau_k / A \ \forall \ k = m, r$, assuming that all surpluses/deficits are redistributed in a lump-sum fashion. To replicate the social planner solution, τ_m and τ_r have to be chosen such that $\tilde{s}_k^{\text{lf}}(\hat{c}_1, \hat{c}_2) = \tilde{s}_k^{\text{sp}}(\hat{c}) \ \forall \ k \in m, r$, where

$$\tilde{s}_m^{\text{lf}}(\hat{c}_1, \hat{c}_2) = \begin{cases} \dfrac{1 + 2\hat{c}_1 + 2\hat{c}_2 - \sqrt{(1 + 2\hat{c}_1 + 2\hat{c}_2)^2 - 8\hat{c}_2}}{2} & \text{for } (a) \quad 0 < \tilde{s}_m^{\text{lf}} < \tilde{s}_r^{\text{lf}} < 1, \\ \hat{c}_1 & \text{for } (b) \quad 0 < \tilde{s}_m^{\text{lf}} < \tilde{s}_r^{\text{lf}} = 1, \end{cases} \tag{9'}$$

and

$$\tilde{s}_r^{\text{lf}}(\hat{c}_1, \hat{c}_2) = \begin{cases} \dfrac{4\hat{c}_2}{1 - 2\hat{c}_1 - 2\hat{c}_2 + \sqrt{(1 + 2\hat{c}_1 + 2\hat{c}_2)^2 - 8\hat{c}_2}} & \text{for } (a) \quad 0 < \tilde{s}_m^{\text{lf}} < \tilde{s}_r^{\text{lf}} < 1, \\ 1 & \text{for } (b) \quad 0 < \tilde{s}_m^{\text{lf}} < \tilde{s}_r^{\text{lf}} = 1. \end{cases} \tag{10'}$$

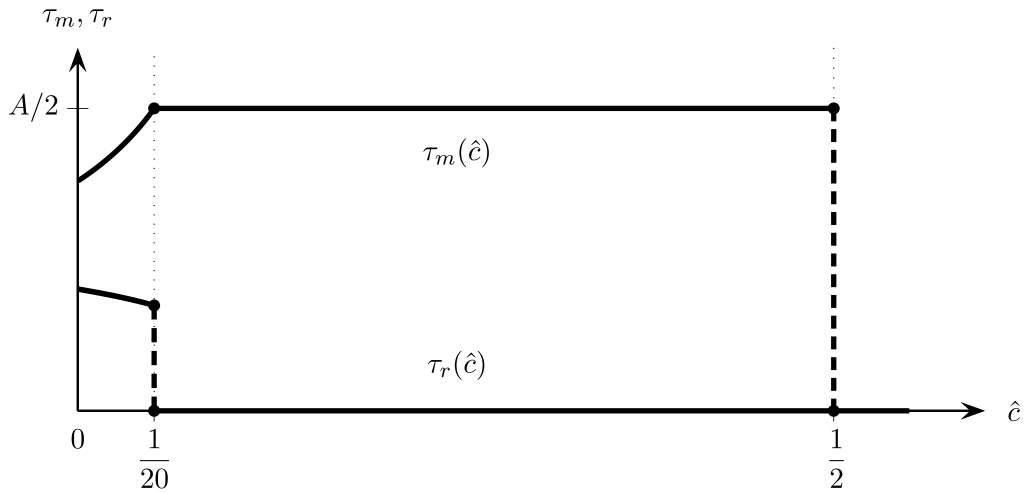
denote the generalised migration and return cutoffs for $c_1 \neq c_2$, which simplify to $\tilde{s}_m^{\text{lf}}(\hat{c})$ in Eq. (9) and $\tilde{s}_m^{\text{lf}}(\hat{c})$ in Eq. (10) for $c_1 = c_2$. We summarise the optimal migration policy in Proposition 4 and illustrate the socially optimal combination of τ_m and τ_r (satisfing $\tilde{s}_k^{\text{lf}}(\hat{c}_1, \hat{c}_2) = \tilde{s}_k^{\text{sp}}(\hat{c}) \ \forall \ k \in m, r$) in Figure 8.

Proposition 4 *The optimal migration policy reduces the number of temporary and permanent migrants by raising the costs of migration either through subsidies to non-migrants and returnees or through taxes on temporary and permanent migrants.*

Proof Analysis and formal discussion in the text. ■

For the empirically relevant scenario with negative selection into return migration the optimal policy mix of τ_m and τ_r in Figure 8 may be understood as arbitrary combinations of subsidies to non-migrants and returnees or taxes levied on temporary and permanent migrants. Thereby it is important to understand that two independent policy instruments are required to separately target the distinct mobility choices of initial and return migrants. Due to the interrelationship between workers' initial migration and initial migrants' later

Figure 8: *Optimal Migration Policies*



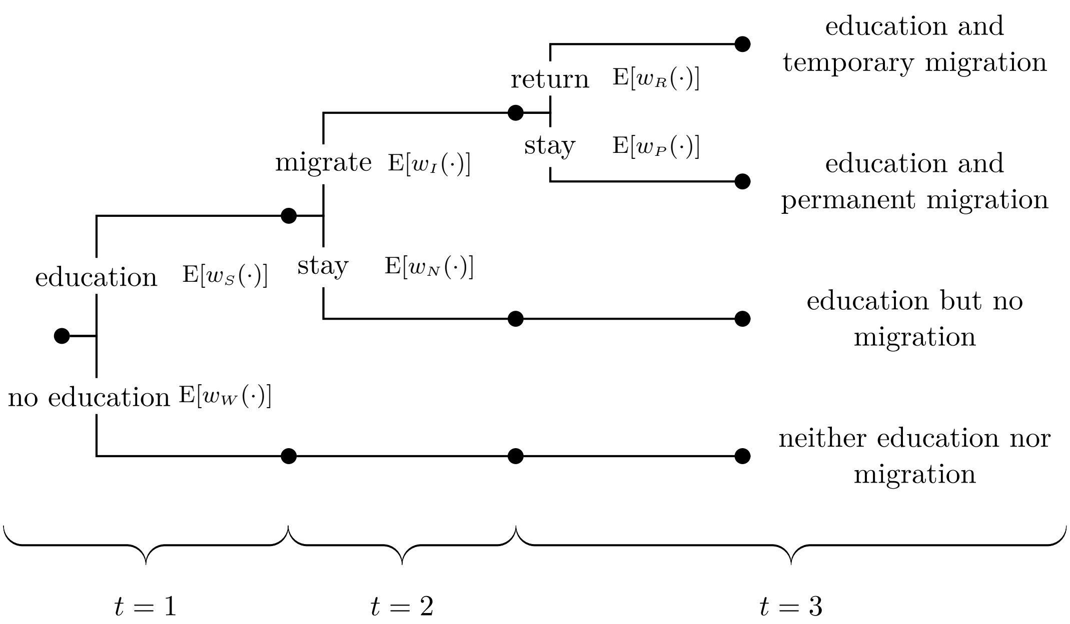
return decision in Eq. (5), each policy instrument simultaneously affects the sub-group of initial migrants and the sub-group of return migrants in their mobility choices. Subsidising only return migration could reduce the number of permanent migrants to the socially optimal level. However, at the same time it would become more attractive for temporary migrants to leave their home region in the first place, which is the reason why a return subsidy always must be complemented by an even stronger subsidy for non-migrants (as illustrated in Figure 8).[15]

5 Alternative Signalling Devices

In this section we show that individuals continue to use temporary and permanent migration as a signal for their otherwise unobservable skills, even when an alternative signalling device (e.g. education as for example in Spence's (1973) seminal signalling model) is available. Adjusting the choice set from Figure 3 to allow individuals to first use an alternative signal before turning to temporary or permanent migration as signalling devices leads us to a three-stage decision problem as illustrated in Figure 9. In addition to the four migrant types (N, I, R, P) from Subsection 3.1, workers can also decide to invest into an alternative signal

[15] In a scenario, in which permanent migration (due to sufficiently high costs c) no longer is a viable option, a constant subsidy of $\tau_m(\hat{c}) = A/2 > 0$ for non-migrants is sufficient to restore optimality (cf. Kreickemeier and Wrona, 2017).

Figure 9: *Education, migration and return decisions*



(indexed by subscript $i = S$) or to proceed without such a signal (indexed by subscript $i = W$). Those workers, who initially signalled then can decide to migrate in the second stage with the option to return in stage three. In order to simplify the analysis we assume the periodical signalling and staying costs to be the same $c > 0$.

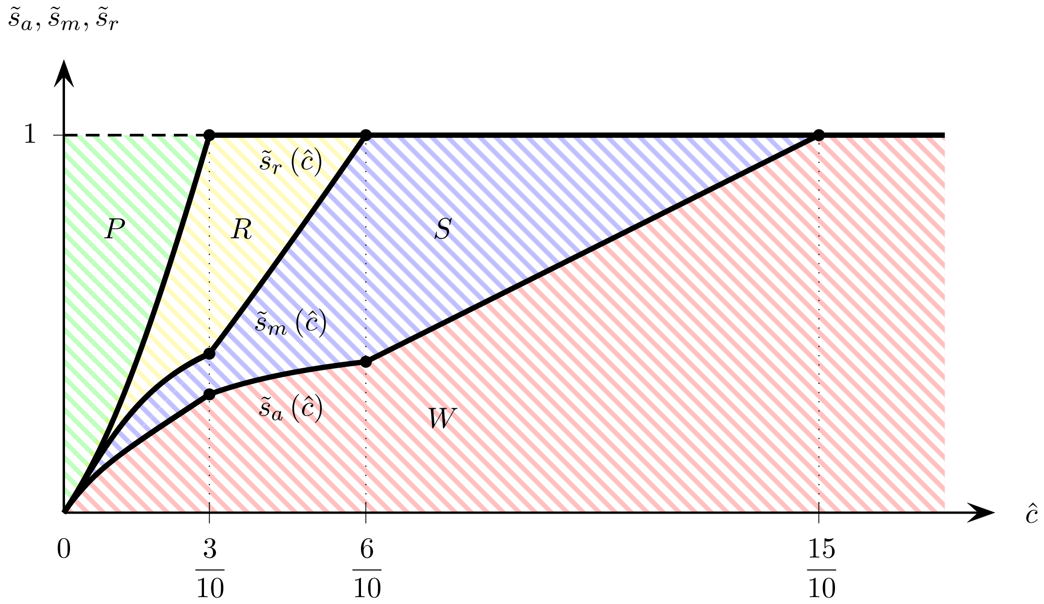
Going through the same steps as in Section 3.3, we can derive Proposition 5, which summarises the selection results, that also we illustrate in Figure 10:

Proposition 5 *For sufficiently low but non-zero cost* $0 < \hat{c} \lessapprox 3/10$ *the most high-skilled workers with* $s \in [\tilde{s}_r, 1]$ *combine the alternative signal with permanent migration. Less skilled workers with* $s \in [\tilde{s}_m, \tilde{s}_r)$ *signal and migrate temporary, while workers with* $s \in [\tilde{s}_a, \tilde{s}_m)$ *invest only into the alternative signal. The least skilled workers with* $s \in [0, \tilde{s}_a)$ *neither signal nor migrate.*

Proof Delegated to Appendix A.3. ■

We illustrate the result from Proposition 5 in Figure 10, which depicts the cut-off skill level for the alternative signal $\tilde{s}_a$ (indexed by subscript a) and the migration cut-offs $\tilde{s}_m$ and $\tilde{s}_r$. We distinguish between permanent and return migrants by P (in green) and R (in yellow) as well as between workers that only use the alternative signal S (in blue) and those workers, which neither signal nor migrate W (in red).

Figure 10: *Alternative Signalling Devices*



While there is some crowding out of temporary and permanent migration if the cost of signalling are high (i.e. $\hat{c} > 6/10$), we generally find that the most high-skilled workers prefer to combine different signalling strategies to reveal as much as possible of their true but otherwise unobservable skills.

6 Conclusion

In this paper we have developed a theory of planned return migration between similar regions, in which the selection into initial and later return migration is derived from a straightforward signalling motive. Workers select strategically into costly temporary and permanent migration to generate a proper signal of their high but otherwise unobservable skills. By observing individual migration histories as an easy-to-verify signal firms can form more efficient production teams, which is reflected by an increase in total output.

Surprisingly, we find that not even the migrants expect to benefit from temporary and permanent migration in comparison to an equilibrium without migration. Responsible for the welfare-reducing effect of temporary and permanent migration is a negative wage externality, which emerges due to skill complementaries in team production. The marginal worker rationally ignores the negative external effects that migration has on other workers' wages. As a consequence we observe sub-optimally high-levels of temporary and permanent migration, which are associated with wasteful migration costs, that more than offset the aggregate production gains from a more efficient matching. An optimal migration policy mix aims for reduced but not necessary zero mobility.

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A Appendix

A.1 Proof of Proposition 2

We show that in any migration equilibrium the expected lifetime income of each worker, i.e. wages $\mathrm{E}[w_i(s_i)|\, s\,]\ \forall\ i \in \{N, I, R, P\}$ in period one and two net of the migration cost c (if applicable) does not exceed expected lifetime income $\mathrm{E}[w(s)|\, s\,] = As/2$ in a equilibrium without migration.

In the high-cost scenario (b) with $1/3 \leq \hat{c} < 1$ we then have:

$$2\,\mathrm{E}[w(s)|\, s\,] \geq \begin{cases} 2\,\mathrm{E}[w_N(s_N)|\, s\,] & \text{if} \quad s < \tilde{s}_m, \\ \mathrm{E}[w_I(s_I)|\, s\,] - c + \mathrm{E}[w_R(s_R)|\, s\,] & \text{if} \quad s \geq \tilde{s}_m. \end{cases} \tag{A.1}$$

Using the definition of $\mathrm{E}[w_i(s_i)|\, s\,]$ from Eq. (3) in combination with $\mathrm{E}[\,s\,] = 1/2 \geq \mathrm{E}[s_N] = \tilde{s}_m/2$ and $\tilde{s}_m = \hat{c}$ from Eq. (9), we can simplify the first inequality in Eq. (A.1) to $\hat{c} \leq 1$. Substituting $\mathrm{E}[s_I] = \mathrm{E}[s_R] = (\tilde{s}_m + 1)/2 \geq \mathrm{E}[s] = 1/2$ and $\tilde{s}_m = \hat{c}$ from Eq. (9) into the second inequality in Eq. (A.1) allows us to solve for $s \leq 1$, which generally holds true, since $s \in [0, 1]$.

Turning to the low-cost scenario (a) for $0 < \hat{c} \leq 1/3$ we can show that:

$$2\,\mathrm{E}[w(s)|\, s\,] \geq \begin{cases} 2\,\mathrm{E}[w_N(s_N)|\, s\,] & \text{if} \quad s < \tilde{s}_m, \\ \mathrm{E}[w_I(s_I)|\, s\,] - c + \mathrm{E}[w_R(s_R)|\, s\,] & \text{if} \quad s \in [\tilde{s}_m, \tilde{s}_r), \\ \mathrm{E}[w_I(s_I)|\, s\,] - c + \mathrm{E}[w_P(s_P)|\, s\,] - c & \text{if} \quad s \geq \tilde{s}_r. \end{cases} \tag{A.2}$$

Using $\mathrm{E}[\,s\,] = 1/2 \geq \mathrm{E}[s_N] = \tilde{s}_m^{\mathrm{lf}}/2$ in combination with $\tilde{s}_m = (1 + 4\hat{c} - \sqrt{1 + 16\hat{c}^2})/2$ from Eq. (9), we can simplify the first inequality in Eq. (A.2) into $\hat{c} \geq 0$. The second inequality in Eq. (A.2) can be rewritten as

$$\lambda\,(s) \equiv 1 - \tilde{s}_m - \frac{1 + \tilde{s}_r}{2} + \frac{\hat{c}}{s} \geq 0,$$

where $\mathrm{E}[\,s\,] = 1/2 \leq \mathrm{E}[s_I] = (\tilde{s}_m + 1)/2$ and $\mathrm{E}[s_R] = (\tilde{s}_m + \tilde{s}_r)/2$ have been used to replace $\mathrm{E}[\,s\,]$, $\mathrm{E}[s_I]$, and $\mathrm{E}[s_R]$. Since $\lambda'(s) < 0$, we have $\lambda\,(s) \geq \lambda\,(1)$ and $\lambda(1) \geq 0$ is sufficient for $\lambda(s) \geq 0$. Using $\tilde{s}_m = (1 + 4\hat{c} - \sqrt{1 + 16\hat{c}^2})/2$ from Eq. (9) and $\tilde{s}_r = 4\hat{c}/(1 - 4\hat{c} + \sqrt{1 + 16\hat{c}^2})$

from Eq. (10) we can show that $\lambda(1) \geq 0$ may equivalently be expressed as $\hat{c} \leq 1/3$. Replacing $\mathrm{E}[\,s\,]$, $\mathrm{E}[s_I]$, and $\mathrm{E}[s_P]$ in the third inequality of Eq. (A.2) by $\mathrm{E}[\,s\,] = 1/2 \leq \mathrm{E}[s_I] = (\tilde{s}_m + 1)/2 < \mathrm{E}[s_P] = (\tilde{s}_r + 1)/2$ yields

$$\mu\,(s) \equiv \frac{4\hat{c}}{s} - \tilde{s}_m - \tilde{s}_r \geq 0.$$

Since $\mu'(s) < 0$, inequality $\mu(1) \geq 0$ is a sufficient condition for $\mu(s) \geq 0$. Using $\tilde{s}_m = (1 + 4\hat{c} - \sqrt{1 + 16\hat{c}^2})/2$ from Eq. (9) and $\tilde{s}_r = 4\hat{c}/(1 - 4\hat{c} + \sqrt{1 + 16\hat{c}^2})/2$ from Eq. (10) we can show that $\mu\,(1) = 0$ and, hence, $\mu(s) \geq 0$. ■

A.2 Proof of Proposition 3

In order to derive $\tilde{s}_m^{\text{sp}}$ and $\tilde{s}_r^{\text{sp}}$ as plotted in Figure 7, we can use the definition of $\mathrm{E}[s_i]\ \forall\ i \in \{N, I, R, P\}$ from Eq. (7) to rewrite the social planner's objective function as:

$$\mathrm{E}[W\,(\tilde{s}_m, \tilde{s}_r)] = \begin{cases} A\tilde{s}_m\tilde{s}_r\,(\tilde{s}_r - \tilde{s}_m)\,/4 + \sum_k A\,[1 + \tilde{s}_k\,(1 - \tilde{s}_k)]\,/4 - (1 - \tilde{s}_k)\,c & \text{for } (a), \\ A\,[1 + \tilde{s}_m\,(1 - \tilde{s}_m)]\,/2 - (1 - \tilde{s}_m)\,c & \text{for } (b), \end{cases} \tag{A.3}$$

with $k = m, r$. The corresponding first order conditions then follow as:

$$\frac{\partial\,\mathrm{E}[W\,(\tilde{s}_m, \tilde{s}_r)]}{\partial \tilde{s}_m} = \frac{A\,(1 - 2\tilde{s}_m + \tilde{s}_r^2 - 2\tilde{s}_m\tilde{s}_r)}{4} + c \stackrel{!}{=} 0 \quad \text{for } (a), \tag{A.4}$$

$$\frac{\partial\,\mathrm{E}[W\,(\tilde{s}_m, \tilde{s}_r)]}{\partial \tilde{s}_r} = \frac{A\,(1 - 2\tilde{s}_r - \tilde{s}_m^2 + 2\tilde{s}_m\tilde{s}_r)}{4} + c \stackrel{!}{=} 0 \quad \text{for } (a), \tag{A.5}$$

$$\frac{\partial\,\mathrm{E}[W\,(\tilde{s}_m, \tilde{s}_r)]}{\partial \tilde{s}_m} = \frac{A\,(1 - 2\tilde{s}_m)}{2} + c \stackrel{!}{=} 0 \quad \text{for } (b). \tag{A.6}$$

Since the return margin is fixed to $\tilde{s}_r^{\text{sp}} = 1$ in the high-cost scenario (b), the social planner only has to choose the optimal emigration cutoff $\tilde{s}_m^{\text{sp}}$, and it follows immediately that $\tilde{s}_m^{\text{sp}}(\hat{c}) = \frac{1}{2} + \tilde{s}_m^{\text{lf}}(\hat{c})$, where $\tilde{s}_m^{\text{lf}}(\hat{c})$ is defined as in Eq. (9). For the low-cost case (a) migration cutoff $\tilde{s}_m^{\text{sp}}(\hat{c})$ and return cutoff $\tilde{s}_r^{\text{sp}}(\hat{c})$ follow as the joint solution to Eqs. (A.4) and (A.5). An explicit analytical solution to Eqs. (A.4) and (A.5) exists. However, instead of reporting the lengthy solutions for $\tilde{s}_m^{\text{sp}}(\hat{c})$ and $\tilde{s}_r^{\text{sp}}(\hat{c})$ here, we rather plot them directly as a function of the only exogenous variable $\hat{c}$ in Figure 7. Of course we thereby have to distinguish between the low-cost case (a) and the high-cost case (b). In order to identify the cost threshold that separates the high cost case (b) from an equilibrium without migration we use $\tilde{s}_m^{\text{sp}}(\hat{c}) = \frac{1}{2} + \tilde{s}_m^{\text{lf}}(\hat{c}) \overset{!}{=} 1$ in combination with $\tilde{s}_m^{\text{lf}}(\hat{c}) = \hat{c}$ from Eq. (9) to identify a critical value of 1/2. Similarly, when focusing on the low-cost case (a) we find that $\tilde{s}_r^{\text{sp}}(\hat{c}) \overset{!}{=} 1$ implies a critical value of approximately 1/20. ■

A.3 Proof of Proposition 5

For symmetric cost $c > 0$ individual signalling/migration decisions in Figure 9 cumulate into four different signalling/migration patterns:

(a) $0 < \tilde{s}_a < \tilde{s}_m < \tilde{s}_r < 1 \;\Rightarrow\;$ *imperfect selection into temporary (permanent) migration*,

(b) $0 < \tilde{s}_a < \tilde{s}_m < \tilde{s}_r = 1 \;\Rightarrow\;$ *imperfect selection into temporary migration only*,

(c) $0 < \tilde{s}_a < \tilde{s}_m = \tilde{s}_r = 1 \;\Rightarrow\;$ *no selection into migration*,

(d) $0 = \tilde{s}_a = \tilde{s}_m = \tilde{s}_r < 1 \;\Rightarrow\;$ *no signalling/migration*,

where $\tilde{s}_a$ denotes the skill cut-off above which individuals select into the alternative signal (indexed by subscript a). In the following each of the non-trivial cases (a), (b), and (c) are solved separately.

We begin with scenario (c), in which only the alternative signal is used. The expected lifetime wage gain from signalling then is given by:

$$\Delta_1^w(s) \equiv \mathrm{E}[w_S(s_S) \,|\, s] + 2\,\mathrm{E}[w_N(s_N) \,|\, s] - 3\,\mathrm{E}[w_W(s_W) \,|\, s].$$

Using $\mathrm{E}[w_i(s_i) | \, s_i]$ from Eq. (3) and replacing $\mathrm{E}[s_W] = \tilde{s}_a/2 < \mathrm{E}[s_S] = \mathrm{E}[s_N = (\tilde{s}_a + 1)/2$ in $\Delta_1^w(\tilde{s}_a) \overset{!}{=} c$ allows us to solve for:

$$\tilde{s}_a(\hat{c}) = \frac{2}{3}\hat{c} \quad \text{for } (c).$$

In scenario (b) the most high-skilled workers with $s \geq \tilde{s}_m$ combine their first round signal with subsequent (temporary) migration in order to obtain a more effective overall signal. Solving by backward induction, we begin with the migration decision at stage two. With the expected wage gain being given by:

$$\Delta_2^w(s) \equiv \mathrm{E}[w_I(s_I) | \, s] + \mathrm{E}[w_R(s_R) | \, s] - 2\,\mathrm{E}[w_N(s_N) | \, s],$$

we can use $\Delta_2^w(\tilde{s}_m) \overset{!}{=} c$ in combination with $\mathrm{E}[w_i(s_i)|\, s_i\,]$ from Eq. (3) and $\mathrm{E}[s_N] = (\tilde{s}_a + \tilde{s}_m)/2 < \mathrm{E}[s_I] = \mathrm{E}[s_R] = (\tilde{s}_m + 1)/2$ in order to solve for:

$$\tilde{s}_m(\tilde{s}_a) = \frac{\hat{c}}{1 - \tilde{s}_a}. \tag{A.7}$$

The expected lifetime wage gain from signalling hence can be computed as:

$$\Delta_1^w(s) \equiv \mathrm{E}[w_S(s_S)\,|\,s\,] + 2\,\mathrm{E}[w_N(s_N)\,|\,s\,] - 3\,\mathrm{E}[w_W(s_W)\,|\,s\,] = A(1 + 2\tilde{s}_m)\tilde{s}_a/2,$$

where we have used $\mathrm{E}[w_i(s_i)|\, s_i\,]$ from Eq. (3) in combination with $\mathrm{E}[s_W] = \tilde{s}_a/2 < \mathrm{E}[s_N] = (\tilde{s}_a + \tilde{s}_m)/2 < \mathrm{E}[s_S] = (\tilde{s}_a + 1)/2$ in order to establish the above equality. Replacing $\tilde{s}_m$ by $\tilde{s}_m(\tilde{s}_a) = \hat{c}/(1 - \tilde{s}_a)$ from Eq. (A.7) in $\Delta_1^w(\tilde{s}_a) \overset{!}{=} c$ finally allows us to solve for:

$$\tilde{s}_a(\hat{c}) = \left(1 + 4\hat{c} - \sqrt{1 + 16\hat{c}^2}\right)/2 \quad \text{for } (b). \tag{A.8}$$

Substituting $\tilde{s}_a(\hat{c})$ from Eq. (A.8) back into $\tilde{s}_m(\tilde{s}_a) = \hat{c}/(1 - \tilde{s}_a)$ from Eq. (A.7) then yields the corresponding migration cutoff:

$$\tilde{s}_m(\hat{c}) = 2\hat{c}/\left(1 + 4\hat{c} - \sqrt{1 + 16\hat{c}^2}\right) \quad \text{for } (b).$$

Finally, in scenario (a) we have $0 < \tilde{s}_e < \tilde{s}_m < \tilde{s}_r < 1$. We solve by backward induction and start at stage $t = 3$ with the expected wage gain from permanent migration being given by:

$$\Delta_3^w(s) \equiv \mathrm{E}[w_P(s_P)|\, s\,] - \mathrm{E}[w_R(s_R)|\, s\,].$$

Using $\mathrm{E}[w_i(s_i)|\, s_i\,]$ from Eq. (3) in combination with $\mathrm{E}[s_R] = (\tilde{s}_m + \tilde{s}_r)/2 < \mathrm{E}[s_P] = (\tilde{s}_r + 1)/2$ in $\Delta_3^w(\tilde{s}_r) \overset{!}{=} c$ allows us to solve for:

$$\tilde{s}_r(\tilde{s}_m) = \frac{2\hat{c}}{1 - \tilde{s}_m}. \tag{A.9}$$

At stage $t = 2$ the expected wage gain from temporary migration is given by:

$$\Delta_2^w(s) \equiv \mathrm{E}[w_I(s_I)|\, s\,] + \mathrm{E}[w_R(s_R)|\, s\,] - 2\,\mathrm{E}[w_N(s_N)|\, s\,].$$

Using $\mathrm{E}[w_i(s_i)|\, s_i\,]$ from Eq. (3) in combination with $\mathrm{E}[s_N] = (\tilde{s}_a + \tilde{s}_m)/2 < \mathrm{E}[s_R] = (\tilde{s}_m + \tilde{s}_r)/2 < \mathrm{E}[s_I] = (\tilde{s}_m + 1)/2$ and $\tilde{s}_r\,(\tilde{s}_m) = 2\hat{c}/(1 - \tilde{s}_m)$ from Eq. (A.9) in $\Delta_2^w\,(\tilde{s}_m) \overset{!}{=} c$ allows us to solve for:

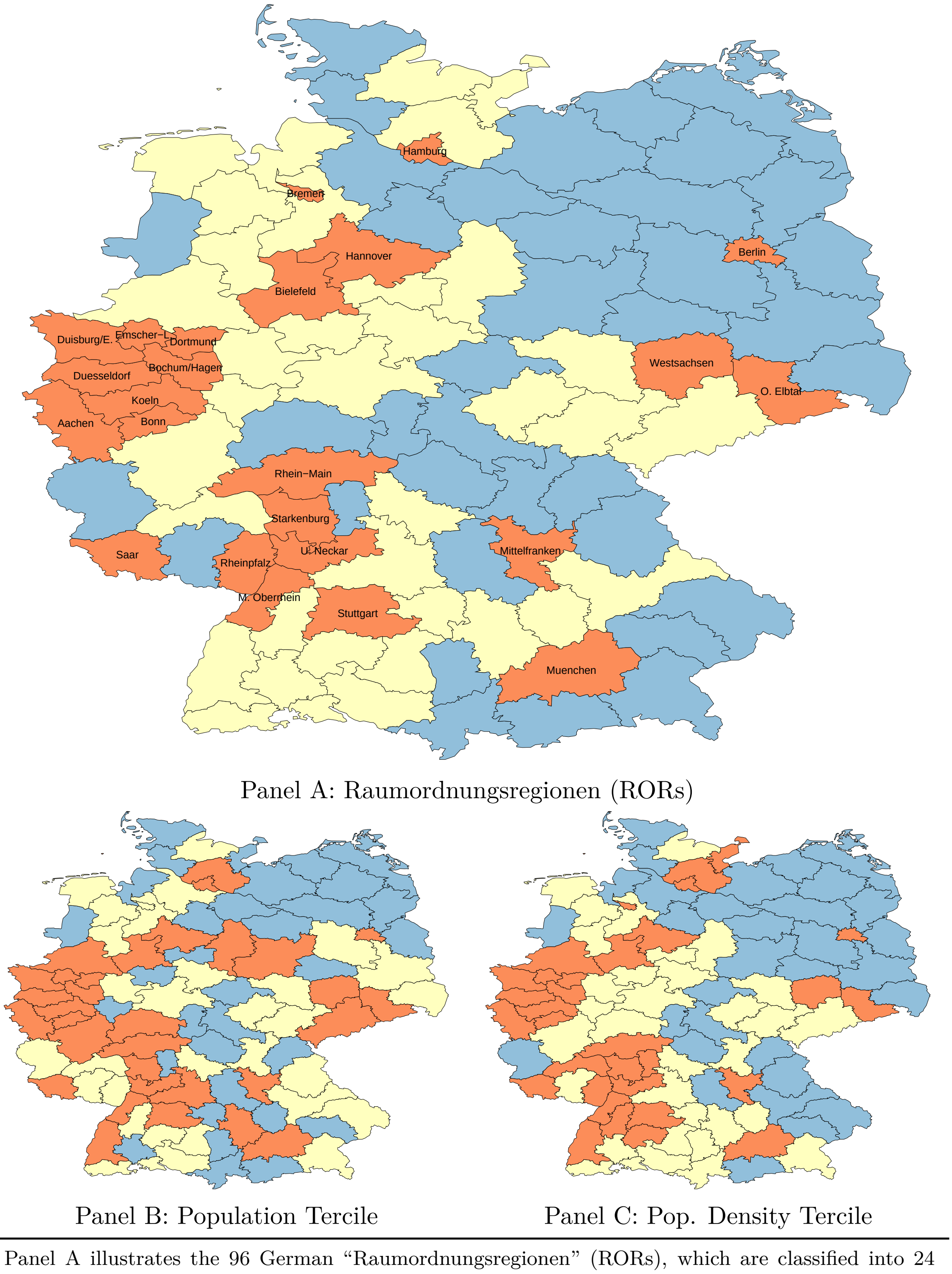
$$\tilde{s}_m = \frac{1 - 2\tilde{s}_a + 4\hat{c} - \sqrt{1 + 16\hat{c}^2 - 4\tilde{s}_a\,(1 - \tilde{s}_a)}}{2\,(1 - 2\tilde{s}_a)}. \tag{A.10}$$

Finally, at stage $t = 1$ the expected lifetime wage gain from signalling is given by:

$$\Delta_1^w\,(s) \equiv \mathrm{E}[w_S(s_S)|\, s\,] + 2\,\mathrm{E}[w_N(s_N)|\, s\,] - 3\,\mathrm{E}[w_W(s_W)|\, s\,].$$

Using $\mathrm{E}[w_i(s_i)|\, s_i\,]$ from Eq. (3) in combination with $\mathrm{E}[s_W] = \tilde{s}_a/2 < \mathrm{E}[s_N] = (\tilde{s}_a + \tilde{s}_m)/2 < \mathrm{E}[s_S] = (\tilde{s}_a + 1)/2$ and $\tilde{s}_m\,(\tilde{s}_a)$ from Eq. (A.9) in $\Delta_1^w\,(\tilde{s}_a) \overset{!}{=} c$ allows us to solve for $\tilde{s}_a(\hat{c})$ as depicted in Figure 10. Substituting $\tilde{s}_a\,(\hat{c})$ back into the Eq. (A.10) then delivers $\tilde{s}_m\,(\hat{c})$ as depicted in Figure 10. Once obtained, $\tilde{s}_m\,(\hat{c})$ from Eq. (A.10) can then be used to replace $\tilde{s}_m$ in $\tilde{s}_r(\tilde{s}_m)$ from Eq. (A.9), which finally results in $\tilde{s}_r\,(\hat{c})$ as depicted in Figure 10. ■

Figure 11: *Classification of Regions*



Panel A: Raumordnungsregionen (RORs)

Panel B: Population Tercile

Panel C: Pop. Density Tercile

Panel A illustrates the 96 German "Raumordnungsregionen" (RORs), which are classified into 24 metropolitan regions (in orange), 35 urbanised regions (in yellow), and 37 rural region (in blue). For comparison we have plotted 2015 population terciles and the population density terciles in the Panels B and C.

Source: Own calculations, Bundesinstitut fr Bau-, Stadt-, und Raumforschung (BBSR).

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